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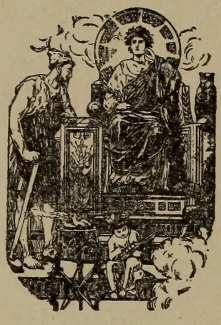

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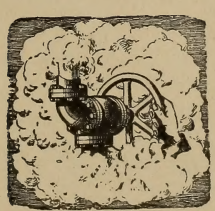

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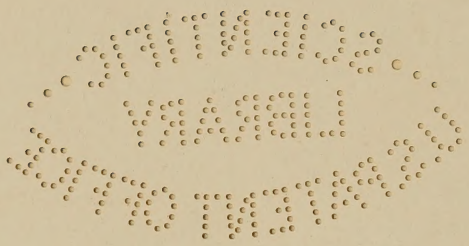

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WALTER H. WHITESIDE

THE NEW PRESIDENT OF THE ALLIS-CHALMERS COMPANY

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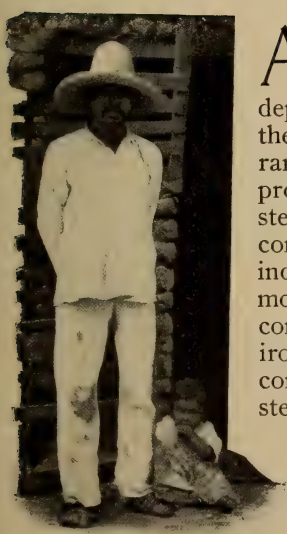
CASSIER'S MAGAZINE

VOL. XXIX NOVEMBER, 1905 No. 1

SOME MEXICAN CHARCOAL BLAST FURNACES

By John Birkinbine



ALTHOUGH Mexico has a number of large deposits of iron ore, the republic does not rank as an important producer of iron and steel. Mexican plants connected with this industry embrace a modern steel plant, constructed to smelt iron ore with coke, convert the metal into steel in open-hearth furnaces and make it into rails, structural shapes, and merchant forms. Another plant has an open-hearth furnace dependent upon scrap and purchased pig iron, and a roll train. There are also several plants in which imported wire is converted into nails, etc.

It is, however, not of these later installations, but of the older plants, depending primarily upon charcoal as fuel, that the writer proposes to tell in this article.

The iron works at Durango may be classed as intermediate between what may be considered the primitive and the modern plants. For many years a cold-blast furnace and a rolling mill were maintained on the Tunal River, about seven miles from the city of Durango, where for about five months in the year there was sufficient water-power to operate the blast furnace, and for another five months the rolling mill could be run. This plant was abandoned after the newer installation, close to the Cerro de Mercado, was started about twenty years ago.

As will be noted from the cut on page 6, the blast furnace, rolling mills, foundry, and machine shop are actually in the shade of the remarkable "iron mountain"; practically all one sees of the cliffs and talus is iron ore. The blast furnace is a banded stone stack, built to use charcoal. Charcoal has been the fuel principally used, although considerable Mexican coke has been fed to the furnaces. However, with facilities offered by railway extensions, the dependence of this plant upon charcoal may be expected. For puddling, Mexican coal is employed, and this mineral is also fed to gas producers for heating. The skilled labour at blast furnace, rolling mill, shops, and

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THE CITY OF DURANGO WITH THE IRON MOUNTAIN IN THE BACKGROUND

foundry is native,—the results obtained reflecting credit upon the capabilities of Mexican labour.

The railroad tracks entering the hacienda, the daily presence of the locomotive to deliver fuel or remove product, the modern steam blowing engine, the hot-blast stove, and the use of mineral fuel in the rolling mill place the Durango plant among the modern types.

Probably no other active blast furnace is located so close to an enormous deposit of rich iron ore as that at Durango. The management report that the average cost of placing one ton of 60 per cent. iron ore in the furnace is about 35 cents, Mexican money. This Cerro de Mercado is fully one mile long, about one-third of a mile wide, and its battlements of ore range from 400 to 650 feet above the level of the works.

The Tula Iron Works, in the State of Michoacán, also has a tinge of modernization in its metal blast-furnace shell mounted on columns, its steam-blowing engine, etc., but the transportation of ore and charcoal on mules and burros or by cart, the shipment of the produce by wagon, the partial dependence upon water-power, the use of kiln-dried wood for puddling, and the general application of manual labour give preponderance to the primitive idea.

Of the Mexican iron works, none rank higher by reason of character of product than those at Zacualtipan and Encarnacion, both in the State of Hidalgo. Ore mined close at hand is smelted with cold blast in stone stacks by means of charcoal burned in the neighbouring forests, the metal being puddled by kiln-dried wood and the rolled product carried in wagons many miles to reach the railroad.

There are several similar plants in Mexico, and a sketch of one making foundry iron about 100 miles northeast of the City of Mexico will give an idea of existing conditions. A cross between a whistle and a hiss, the signal common with Mexican drivers, as an accompaniment to a crack of the whip by the "cochero,"

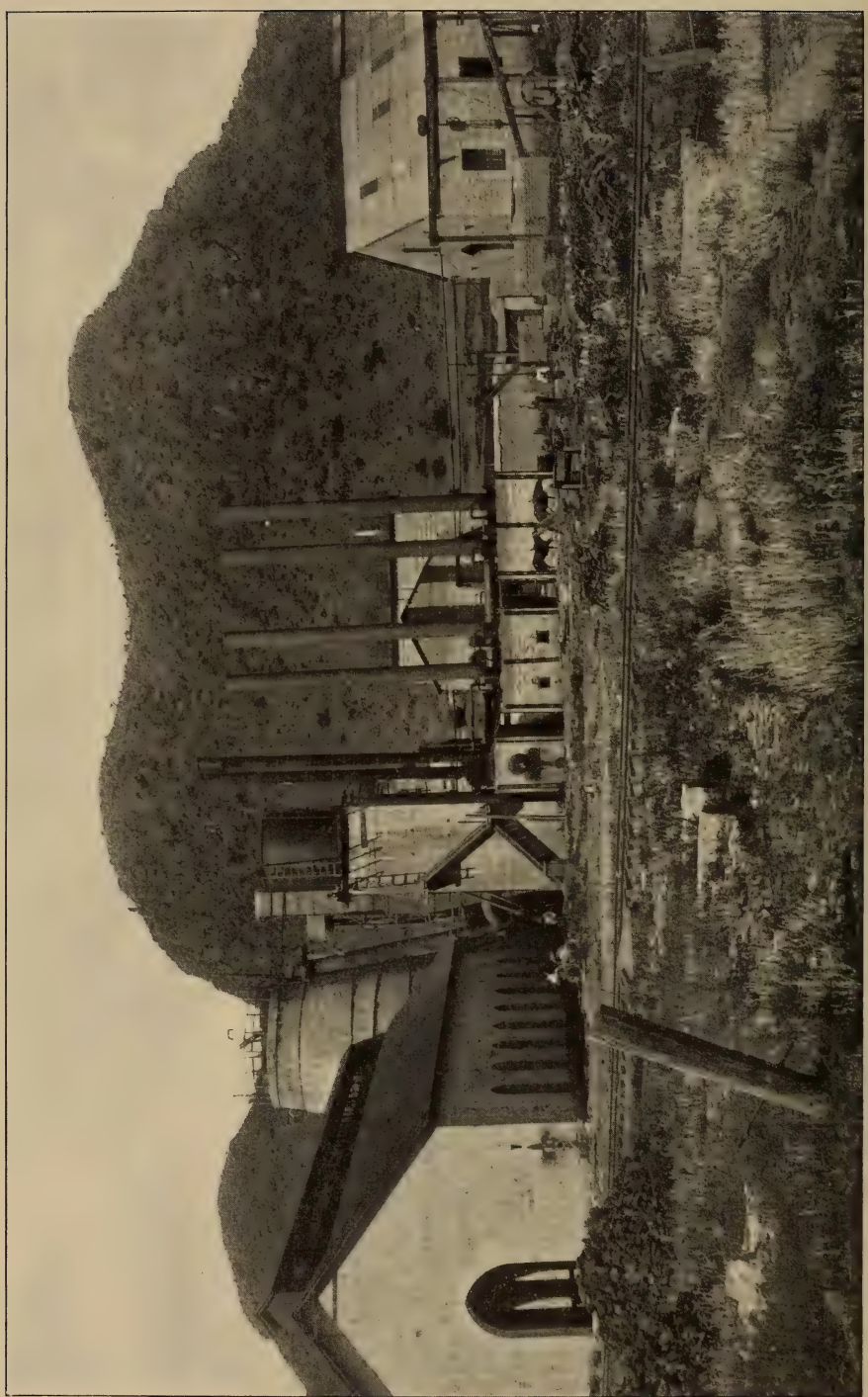
started the five mules attached to the "coche" on the lope, which quickly covered the four kilometers from the present terminus of the Panuco division of the Ferrocarril Central de Mexico to the Apulco Iron Works, and on rounding a curve the interesting installation of Fundacion de Apulco was seen nestling in a barranca or deep ravine, where it was originally located forty years ago to utilize a water-power. The journey was easy compared with one made twelve years before, when twenty-two leagues had to be covered by wagon travel from the terminus of the Hidalgo Railroad near Tulancingo.

Comparatively few changes were noted at first glance. The aggregation of adobe buildings within the walled enclosures of the hacienda were covered with the same long-split narrow wooden shingles, held in place by wooden pins.

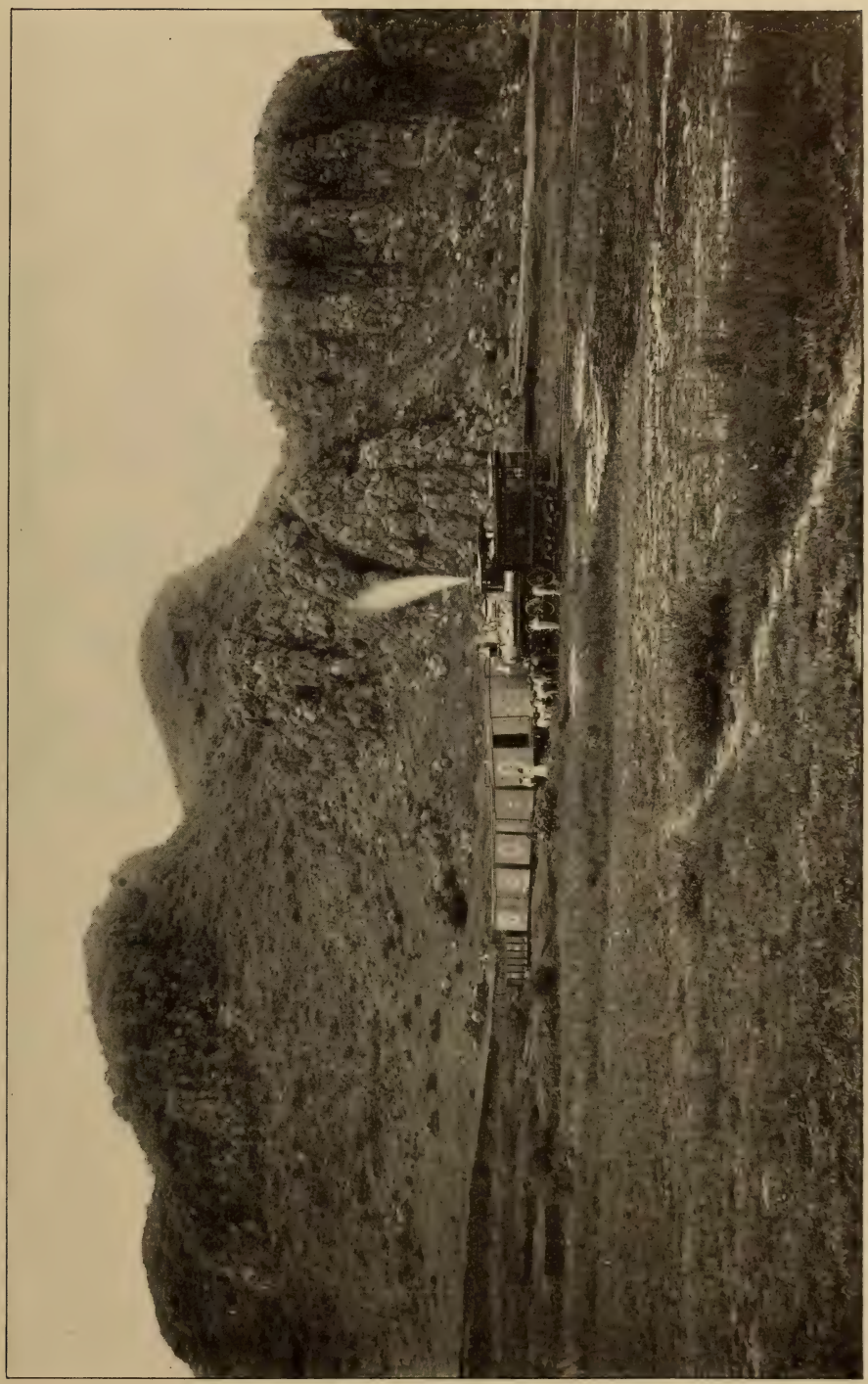
The same blast-furnace stack, built partly of stone and partly adobe, and braced by wooden supports, was hand-fed and tapped as before to make varied castings. Ponderous wagons drawn by ten or twelve mules were being loaded with the furnace products, and droves of mules or burros laden with sacks of ore, charcoal, and limestone brayed impatiently while their drivers stopped to spend a centavo for a drink of pulque.

But detailed inspection showed interesting advances; the old overshot water-wheel, 32 feet in diameter and 4 feet face, had been replaced by a Pelton wheel. This wheel is supplied with water under a 300-foot head, conveyed to it through two leagues of ditch and a line of 12-inch pipes half a mile long, the sections of which were cast at the furnace. This wheel is geared down so as to operate a pair of horizontal iron-blowing cylinders, 42 inches in diameter and 3 feet 6 inches in stroke,

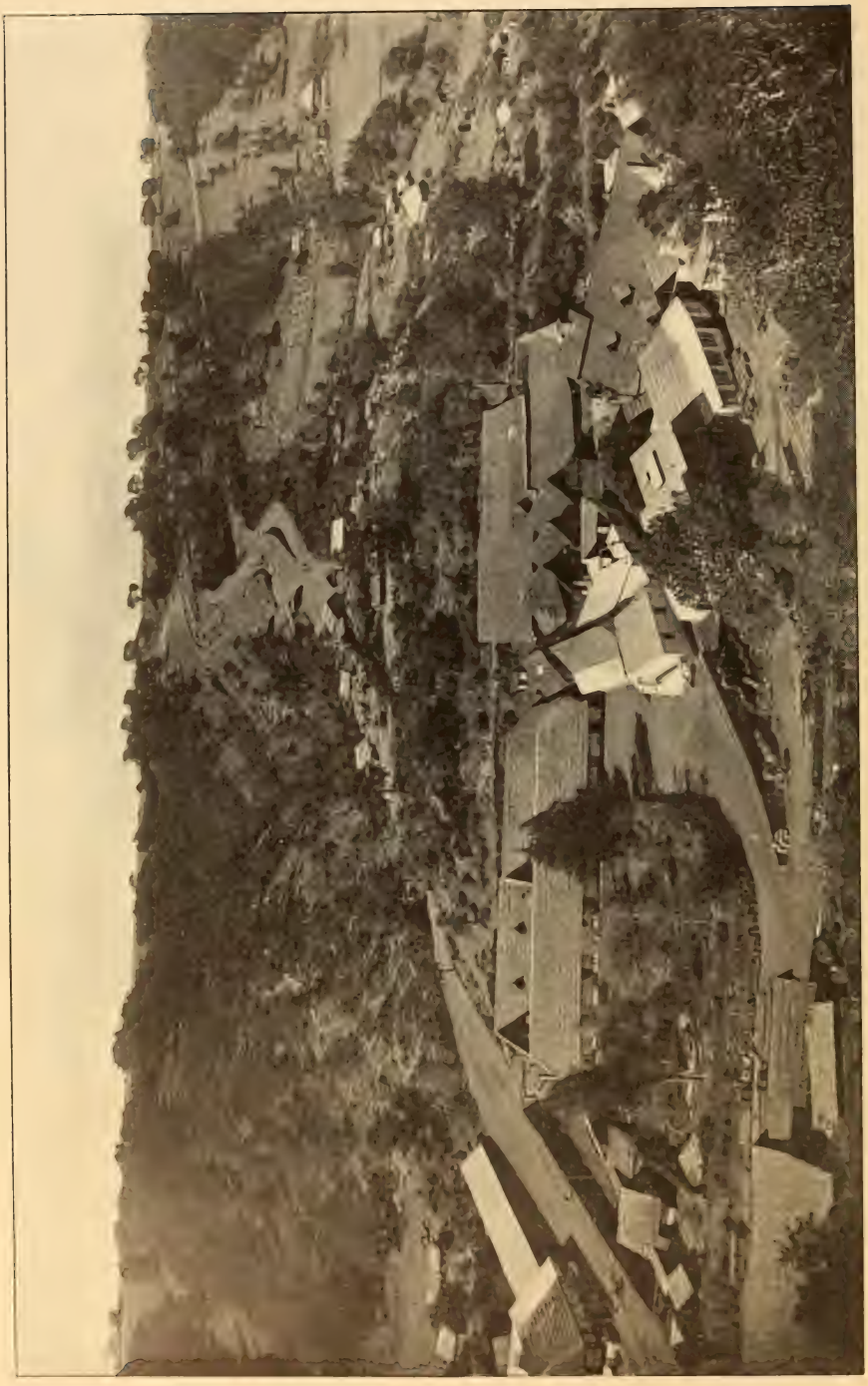
THE PIEDRA AZUL IRON WORKS ON THE TUNAL RIVER NEAR DURANGO, MEXICO, NOW ABANDONED



THE PRESENT FURNACE AT THE FOOT OF IRON MOUNTAIN JUST OUTSIDE OF DURANGO, SHOWING THE FURNACE TO BE VERY CLOSE TO THIS ENORMOUS SUPPLY OF MINERAL



AT THE RIGHT OF THE FURNACE. A NEARER VIEW OF THE MOUNTAIN AND THE RAILWAY LEADING TO IT



THE APELCO IRON WORKS AND SURROUNDINGS IN CENTRAL MEXICO, ABOUT 100 MILES NORTHEAST OF MEXICO CITY

at 20 revolutions per minute. From these air is delivered into a large wooden box strongly braced, and then led to the two tuyere arches formed in the sides of the furnace stack. As the old-fashioned open-shape tuyere is used, a liberal proportion of the blast is deflected.

The blast-furnace stack is 40 feet high and has a bosh diameter of 9 feet, the crucible when relined being 30 inches in diameter. The open fore-hearth is covered by a dam-plate, which is removed and the furnace worked periodically, the operation of the furnace being identical with the procedure followed a half century or more ago at the cold-blast charcoal furnaces in the United States.

Ore, charcoal and flux are conveyed to the furnace in sacks on the backs of burros and mules, each sack as received being weighed by steelyard. The charcoal, owing to the method of charring and transporting it from five to ten miles, is much broken and there is considerable loss in braize. The sacks of charcoal are emptied into storage sheds, and those containing ore and limestone are discharged into bins, at the bottom of which women break the mineral and flux into walnut size with hand-hammers, working only in daytime. They receive a few centavos for a measured quantity dumped into a lower series of bins, from which the furnace is charged. All ingredients are measured, not weighed, although the receptacles being uniformly filled give close approximations to actual weight.

When visited, the Apulco furnace was fed from eighteen to twenty-two charges per day, each consisting of five leather bags (chiquihuites) of charcoal, containing 42 kilos (92 pounds), 17 to 17½ boxes (cajones) of ore, 1½ similar cajones of limestone, a half cajone of cast scrap iron, and another of ore screenings. Each of the cajones contains 22 kilos (48 pounds) of ore or stone.

The charge therefore approximates 460 pounds of charcoal, 800 pounds of ore and scrap iron, and 70 pounds flux. The yield of ore approximates about 50 per cent. metallic iron, and the fuel consumption is about 2300 pounds per metric ton of product.

The labourer who sifts the charcoal fills the chiquihuites, but the two chargers fill the cajones with ore and flux. All the materials are carried to and cast into the open-furnace throat by hand; in fact, no labour-saving appliances are used, a condition which will be appreciated when it is stated that the ordinary daily wage rate for labourers ranges from 31 to 37½ centavos,—equivalent to from 15 to 18 cents, American money. All the employees are Mexican, and no English is heard about the works.

An interesting feature of the plant is that practically the entire output, about four tons per day, is in castings made direct from the furnace. Many of these are quite light, such as ornamental railings, seats for plazas, braseros for cooking or heating with charcoal, plow-points, etc., but some are heavy, such as water pipes up to 24 inches in diameter, columns, etc.

The fracture of the iron shows its good quality, and the perfection of workmanship illustrates the capabilities of the Mexican foundrymen. An equipment of modern tools in the machine and wood-working shops, which contrasts with the crude appliances about the blast furnace, is also well handled by Mexicans.

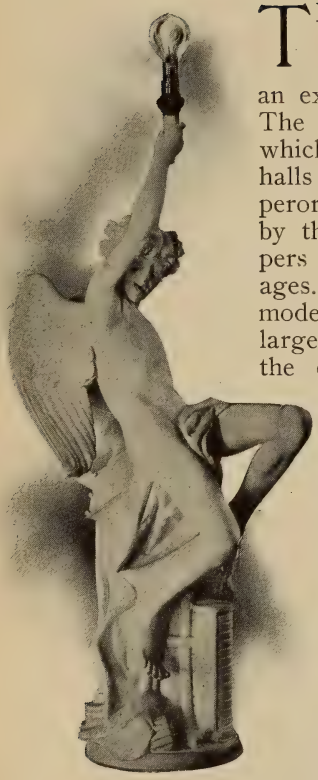
That such a plant is profitably operated within 100 miles of Mexico City, while a modern steel plant 640 miles from the capital and connected with it by competing railways is but partially worked, is explained by existing conditions, for in Mexico labour is overabundant and commands low wages, while fuel is generally scarce and costly, and markets for large outputs must be developed.

The past twenty-three years have shown marvellous advances in Mexico, and the railways have done much to bring these changes about. It

was the writer's privilege to travel extensively through Mexico in advance of the railroad invasion; then a wage rate of 25 centavos per day prevailed in sections where 50 to 75 centavos per day are now paid; mechanics who then wrought for 50 centavos receive $1.50 to $2.00, and puddlers are now paid $4.50 per ton at Durango.

SCIENTIFIC ILLUMINATION

By S. Morgan Bushnell



THE development of scientific illumination has been an extremely slow one. The flaming torches which illuminated the halls of the Roman emperors were succeeded by the candles and tapers of the mediaeval ages. These, in more modern times, were largely supplanted by the oil lamp and the flickering gas jet.

Within the past twenty-five years there have been many improvements in the construction of oil lamps and incandescent gas burners, largely stimulated by the sudden advent of electricity in the field of illumination. The era of electricity came none too soon. The developments of modern civilization along other lines, the rapid increase of population in all large cities, and the complexity of modern life emphasized the need of an artificial light which would produce satisfactory illumination and at the same time be soft and agreeable to the eye.

This is an age of eye glasses. Walk down the street of any large city and you will find that the majority of the people whom you meet are either wearing glasses or have had more or less trouble with their eyes. It is a startling fact, that today there are in the United States more than 50,000 people who are totally blind, while thousands of others are crippled in their capacity for work on account of imperfect vision. While this condition would be serious if it were merely a matter of eyesight, it is still more so in view of the fact that these eye troubles not only affect the eye itself, but by reflex action, cause nervousness, indigestion and many other ailments. In recent years a great many chronic cases of ill health have been found to be due entirely to eye strain, and as soon as relief has been brought to the eyes the patients have, in a short time, recovered. In many of these cases it was only by expert examination that the trouble in the eyes was discovered, the patient having supposed that the eyes were perfectly normal. The conditions of life in a large city are such as to produce undue strain on the organs of sight. A moment's reflection will show some of the reasons why this is so.

In the early development of artificial lighting, the thought was to simply replace darkness with light, and the tendency was to get along with as little light as possible. In the development of modern electric lighting, there has been a tendency to have even a surplus amount of light,

especially in the case of shops and public places, in order to produce a glittering and attractive display. With this condition has come the necessity of laying a greater emphasis on the conditions for hygienic illumination.

The light which nature furnishes, is that of the sun, but the direct rays of the sunlight are by no means the most restful for the eye. The light which we enjoy most is the light we receive from the blue sky above and which has been tempered by a thousand inter-reflections between the green fields and the air above them. It has been shown over and over again by experience that the red rays are the most irritating to the eye, while the blue and the green are the most restful. If nature had provided this planet with red sky and yellow grass, it is very possible that she would also have developed eyes adapted to continuously gazing on these colours. However, for ages past mankind has developed under a blue sky and wandered over green fields or reposed under the denser green of forest foliage. The result has been that the eye has become accustomed to a light entirely different from that supplied by the ordinary incandescent lamp.

In order to note the predominance of red rays in the incandescent lamp, turn on the lamp in competition with daylight. The difference in the quality of light will be seen at a single glance. When we compare artificial with natural light we find several differences. First, the predominance of red and yellow rays is one of the chief disadvantages of artificial light and this disadvantage is found especially in the ordinary gas jet and incandescent electric lamp. In the second place, natural light has an advantage over artificial light in the fact that it is so thoroughly diffused.

The light which shines in at the north window on a summer day does not come from any one spot, but shines in from every direction as far as the eye can reach. Consequently the light which falls upon your table is the result of millions of complex inter-reflections which would defy computation by mathematical formulæ. As a result of this diffused illumination, the objects are clearly defined, but at the same time there are no vivid rays of light impinging on the retina of the eye.

With the present forms of electric incandescent and arc lighting in general commercial use, we find just the reverse condition. The light proceeds from various points of intense brightness, and while these points are modified to a certain extent by the use of shades and reflectors, the modifying effect is only partial.

A third disadvantage in the use of artificial light, is the fact that it is frequently so placed that the light shines directly in the eyes of the beholder. It has been found by experience that the above condition invariably causes strain on the eyes. In well-lighted halls and apartments, the lights are always placed so as not to shine directly into the eyes, and where it is designed to use the light for close work, the lamp should be so placed that the reflection will be away from the eye. The foregoing may be summed up in three cardinal rules for electric lighting:—

First, light should be diffused.

Second, it should have the proper mixture of the various colours of rays.

Third, it should be so placed as to reflect from the eye rather than towards it.

At first consideration it might seem a comparatively simple thing to follow these three rules, but the moment we try to apply them to particular cases, we meet with practical difficulties. It is these difficulties which the inventive genius of the electrical engineer must overcome. Already steps have been taken in this direction. For example, the old scheme of studded lights around shop windows is giving place to concealed lights with mirror reflectors placed at the top of the window. The beholder, instead

of being dazzled by the glare and glitter of a hundred lights, has his attention called to an attractive window display illuminated from unseen sources and giving pleasing and restful effect to the eyes.

The present movement toward cove lighting is another move in the right direction, but we should go further, we should not only have lights concealed around the sides of the room as is the custom, but chandeliers should be designed which will reflect the light to the ceiling without allowing the direct rays to strike the eyes. The Cooper Hewitt mercury vapour lamps and the Moore vacuum tubes are other evidences of progress in the right direction. In both of these styles of lamps, we have a large light-giving surface with an increase in softness and pleasing qualities. During the past five years there has been a very marked increase in the use of frosted lamps, Holophane shades and similar devices for producing a diffused lighting.

Another feature which is now receiving more attention than in the past is the matter of quality or colour of the light. It is well known that the apparent colour of an object is very greatly affected by the kind of light it receives. We have all noticed in spectacular productions on the stage that where the costumes are white or nearly so, it is possible to change them to almost any colour by simply throwing light of that particular colour on the scene.

On the other hand, if the costumes are of any other colour than white, we sometimes get very unexpected effects. For example, if the costume is green, and a red light be thrown upon it, the costume would appear perfectly black, there being no red to reflect the red rays, and no green rays to be reflected from the green material.

That the incandescent light is especially abundant in red rays is shown by the fact that everyone has a much ruddier complexion when seen at night in a well-lighted theater or ballroom than in the daylight. We must bear in mind, however, that this red light is much more trying to the eyes than the whiter light of the daylight. It has been found by experience that the pale white light which shines in at a north window on a summer's day gives for practical purposes the best illumination and at the same time is the most agreeable to the eye.

The question arises, "Is it possible to provide this quality of light artificially, or is nature so far ahead of art in this respect that she can never be approached?"

At the present day we are a long distance from this ideal light, but at the same time the problem of how to secure it is not necessarily an impossible one. Here is a broad field for invention. The problem is to secure a soft light evenly diffused over a large area and of such a quality as to produce the clearest illumination and at the same time be the most soothing to the eye. Of course, it is impossible to construct an azure dome like the one which nature has arched above the earth and which plays such an important part in natural lighting, but at the same time we need not say necessarily that a substitute may not be found which will produce a similar effect in the artificial illumination of interiors.

MODERN BRITISH HIGH-SPEED STEAM ENGINES

By Leo H. Jackson

PART IV.—SOME SPECIAL TYPES

Part I., in the August Number, was Devoted to a Discussion of the Typical Features of Engines of this Class. Parts II. and III., in the September and October Numbers, were Devoted to Examples of Current Practice.

READERS of the several articles on this subject in the August, September and October issues of this magazine, cannot have failed to notice the striking similarity, almost amounting to complete identity in design, which prevailed throughout the group of examples then presented. Such unanimity in the standard practice of nearly all of the prominent makers not only points to a common origin, but,—and this is a vastly more important feature,—testifies, as loudly as facts can speak, to the continued and increasing success of the system of double-acting cylinders combined with forced lubrication. A survey of British practice in high-speed engines, however, which failed to notice three original and isolated types,—the Willans, the Peache and the Scott—would have fulfilled its object but very imperfectly.

THE WILLANS ENGINE

Foremost amongst these three types in importance is the Willans, which has to its credit more than half a million horse-power in use at the present time for electric lighting and tramway work.

The Willans central valve engine, now manufactured by the firm of Willans & Robinson, Ltd., Victoria Works, Rugby, is an enduring memorial to the energy and research of the late M. P. W. Willans, one of the most original and far-sighted of British engineers, whose premature death by accident was universally felt to be a distinct loss to the science of steam engineering. His early labours, however, have borne fruit in the world-wide disseminations of the peculiar type of high-speed engine associated with his name.

For years a good-humored rivalry subsisted between the advocates of double action with forced lubrication, and single action with constant thrust. The relative merits of the two systems have been exhaustively discussed, but without carrying conviction to any useful degree into the minds of either party, and to this day, though the two systems have been in use side by side for twenty years and more, the point is undecided.

The method of lubrication under pressure has proved to be perfectly adapted to the requirements of a double-acting engine, the reversals of stress at the top and at the bottom of the stroke affording exactly the desired opportunity for a fresh film or layer of oil to place itself between brass and journal twice in each revolution. In the Willans engine we are confronted with a totally different set of conditions.

The engine being single-acting there is no reversal of stress, and the pressure on the pins and journals is always in one direction,—downwards; hence there is no need for upper brasses for the main bearings, nor for lower brasses for the connecting-rod large ends. These parts take the form of narrow caps, the

journals and pins being thus left uncovered and exposed for more than half the time to free contact with the lubricant, —a mixture of oil and water with which the enclosed crank chamber is partly filled. The splashing of the cranks into this fluid at the high speed of rotation employed is sufficient, as may be imagined, to thoroughly permeate even the minutest crevices within the casing with the slippery compound. So much for the lubrication which, both in principle and in practice, is simplicity itself.

The general design of the Willans engine is so well known that we shall confine ourselves to a brief description of its action. The engine before us is a triple-expansion engine. It is built in both two-crank and three-crank styles. For large powers the three-crank type is usually employed, there being thus nine steam cylinders in use, the cranks being set 120 degrees apart. This arrangement has the advantage of perfectly balancing the reciprocating part, and of dividing up the cylinders and other parts of the engine into units of manageable size.

The steam is distributed throughout by the hollow piston-rod or "trunk *R*, Fig. 22. It enters from the steam chest at the top by the upper set of oblique

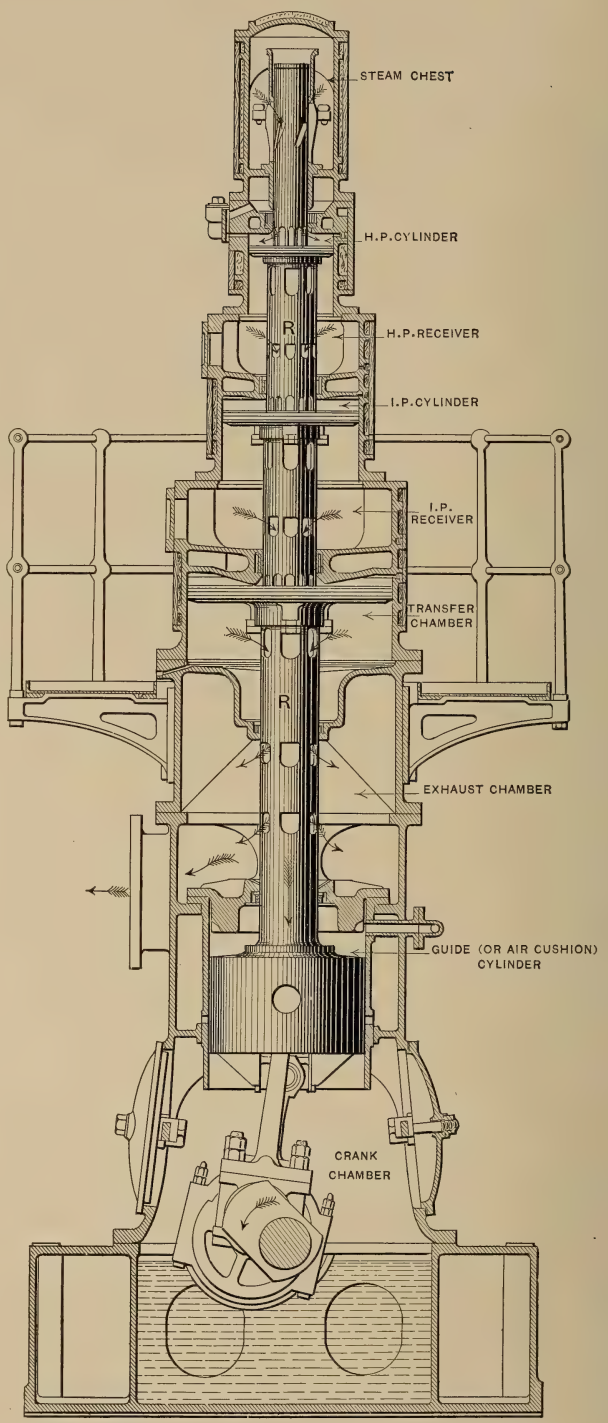


FIG. 22.—SECTION OF A TRIPLE EXPANSION WILLANS ENGINE, BUILT BY WILLANS & ROBINSON, LTD., VICTORIA WORKS, RUGBY

cut-off ports, as shown by the arrows. By the movement of the line of piston valves which works inside the piston-rod (driven by the eccentric-rod shown) the steam passes into the high-pressure cylinder at the beginning of the stroke by the holes or ports shown just above the high-pressure piston. It is important to remember that this ring of ports is the only inlet to and outlet from the cylinder, and that it moves up and down with the piston. After the steam has worked expansively in the high-pressure cylinder the valve passes above the ports and opens communication from the working end of the cylinder, *i. e.,* the space above the piston, to the space below it, which is called the high-pressure receiver, but which is equally a steam-chest for the intermediate cylinder. During the up-stroke the steam is simply transferred from one side of the piston to the other; the whole cylinder, including the "working end," at that time forms part of the receiver.

When the next down-stroke commences, the steam in the high-pressure receiver is passed into the intermediate cylinder. It enters the hollow piston-rod again from the receiver by the ring of short, square-headed holes shown, and passes from the piston-rod to the cylinder by the ring of ports shown just above the intermediate piston. Cut-off in this case is given by the square-headed ports passing into the gland in the intermediate cylinder cover, and so losing the supply of steam from the high-pressure receiver (*i. e.,* the intermediate steam-chest). The cycle is exactly the same as already described for the high-pressure cylinder, and at the end of the second revolution the steam fills the intermediate receiver. Thence, in the third revolution it passes into the low-pressure cylinder; and in the second, or exhaust, half of that revolution it passes from the low-pressure cylinder, *i. e.,* from its upper end to the lower end, of course, without material change of volume or pressure. It is only during the first half of the fourth revolution that it finally passes away from the "transfer chamber" to the "exhaust chamber," the latter being in permanent communication with the condenser.

The full cycle thus described is that of a triple-expansion Cornish engine. In each separate stage of the expansion the complete Cornish cycle can be traced, and it is evidenced by two separate diagrams from the upper and lower end of each cylinder. The diagram from each receiver, or from the "transfer chamber," represents (as in every Cornish engine) work done upon the up-stroke; but it indirectly contributes to the power of the engine, for on the up-stroke the piston is *in equilibrio* while the removal of back-pressure on the down-stroke is a virtual addition to the size of the diagram from the upper end of the cylinder. The advantage is that the total range of temperature due to each stage of expansion does not take effect in the working cylinder, but only part of it. Part of the temperature range acts in the receiver only, where it does little harm. The limitation of the temperature range in the working cylinder is, of course, a clear gain in the matter of initial condensation.

The cushioning arrangement is special to the Willans engine. The guides take the form of bored cylinders, and the crossheads are pistons without rings. The top of the guide cylinder is closed, and on the up-stroke the air in it is compressed to the extent necessary to cushion the pistons and other parts. The power stored in the air by compression on the up-stroke is given out again during the immediately succeeding down-stroke without sensible loss.

The line of valves is driven by an eccentric on the crank-pin. It is necessary that the source of motion for the valves should itself move up and down with the pistons, since the ports which have to be opened and

closed also move up and down. There are two connecting-rods to each line of pistons, one on each side the eccentric; the eccentric rod plays between them. The cranks and all working parts, except the cylinders and valves, are lubricated by the splash of the cranks in the crank-chamber, where the lubricant is usually a mixture of oil and water.

The jacketed receiving bottoms, shown in Fig. 22, are now omitted, as, like all attempts to improve the Willans engine by steam-jacketing, the gain has been found to be exactly balanced by the loss through condensation in the jackets.

The noticeably concave-shape of the upper surfaces of the pistons is designed to aid the drainage of the cylinders. The water is rushed out with the exhausting steam continuously during the upward stroke. When variable expansion is required, which may be either automatic through the action of the governor, or effected as desired by hand, the ports through the hollow piston-rod instead of being square topped and disappearing through a gland are made inclined or spiral in form, and are surrounded by a sleeve capable of rotation and formed with correspondingly inclined or spiral ports. The cut-off is then effected by turning this sleeve to the required position.

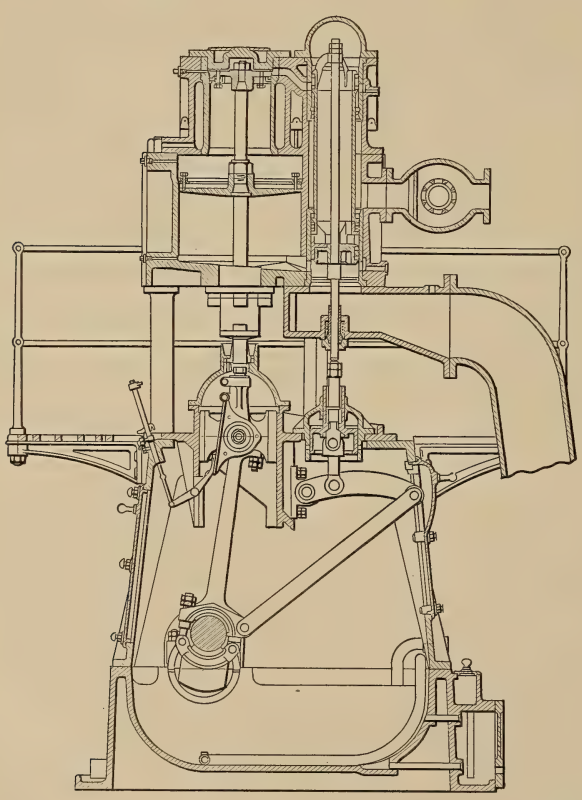


FIG. 23.—A CROSS-SECTION OF THE PEACHE ENGINE, BUILT BY MESSRS. DAVEY, PAXMAN & CO., LTD., COLCHESTER

THE PEACHE ENGINE

The Peache engine, built by Messrs. Davey, Paxman & Co., Ltd., of Colchester, is a single-acting, constant-thrust engine, despite the fact that in its tandem-placed cylinders the steam acts upon the under side of the low-pressure piston during the up-stroke. This apparent paradox at the beginning prepares us in some measure for the series of unique mechanical devices which constitute the working parts of the Peache high-speed engine.

Referring to the cross-section in Fig. 23, which shows the complete engine (usually triplicated) perhaps the first thing which strikes us is the peculiar position of the crank-shaft, which lies some distance in front of the center line of the cylinders. As the direction of rotation is clockwise, it will be seen that on the downward or working stroke, the connecting-rod is more or less in a straight line with the vertical axis of the engine. The friction due to pressure on the cross-head slides is thus very much reduced, if not entirely eliminated.

During the up-stroke, the balance of steam

pressure downwards is sufficient only to absorb the inertia of the reciprocating parts; hence, though the connecting rod is then at a considerable angle, the cross-head pressure is again negligible. On both strokes the pressure is evidently all the time on the back-slide, so that there is no knock in passing the centers under any circumstances.

The cross-head is attached to the piston-rod in an unusual way, by a split boss tightened up by two cross bolts. The cross-head pin is tubular, tapered internally at both ends, and fixed in the cross-head by means of a through bolt having a tapered or conical head, and a loose washer, or sleeve, of corresponding shape, so that by screwing up the lock-nuts the pin is expanded sufficiently to ensure a firm hold in the eyes of the cross-head.

The short tubular trunk forming the cross-head slides is fitted with a dome, bushed for the piston-rod to pass through so as to keep the lubricant from splashing out of the crank-chamber. The connecting-rod being always in compression and lubricated by the splash, is provided only with half brasses of the full width, both at the large and small ends, the corresponding halves being merely narnow "keeps," thus allowing the lubricant free access to the surfaces of the crank-throw journal and cross-head pin. The manner of securing the lower keep by a hinged joint, is worthy of attention, as also is the method of actuating the indicator gear by an inclined face upon the cross-head and a rat-tailed lever.

No eccentrics are employed in the Peache engine, the valve being worked, as shown, by a curved lever jointed by a link to the big end of the connecting-rod. It is claimed that a quicker cut-off in the high, and a later cut-off in the low-pressure cylinder are obtained by this means than by an eccentric, while there is an undoubted advantage in the additional length and simplification of the main bearings. These latter, like the connecting-rod bearings, are only half-encircled by the actual brasses, and for the same reason. The rather elaborate guide at the bottom of the valve-rod, forming a piston working in a short cylinder, acts as an air buffer or dashpot, its object being to maintain a constant downward pressure on the link-work of the valve motion.

Now, as to the method of working the steam through the cylinders, if the reader will imagine the working parts in the cross-section to be in motion, and the crank-shaft to be slowly revolving in the direction of the hands of a watch, the pistons just beginning their descent, we shall be able to describe the Peache steam cycle without difficulty.

The steam entering from the throttle valve shown in section on the right, passes around the tubular-valve distance piece, upwards, and enters the high-pressure cylinder by the port above the piston as the valve rises; it is cut off as the valve falls, at a suitable point in the down-stroke of the piston. Near the bottom of the stroke, the valve, still falling, uncovers the high-pressure part to the receiver, which extends from the dome through the valve to the diaphragm between the two bottom sets of rings. Admission to the low-pressure cylinder, under the piston, begins as the bottom valve uncovers the lower port, and cut-off occurs as it arises. At the top of the stroke, the valve still rising, uncovers the low-pressure port to exhaust, which continues through most of the down-stroke.

High-pressure steam thus acts on the top of the high-pressure piston, and low-pressure steam on the under side of the low-pressure piston. Constant thrust downward is insured by the steam pressure in the intermediate space between the two pistons, called the controlling cylinder. At the top of the stroke the high-pressure piston uncovers by-pass ports in the bore of the cylinder, (not shown in the engraving) which allows steam

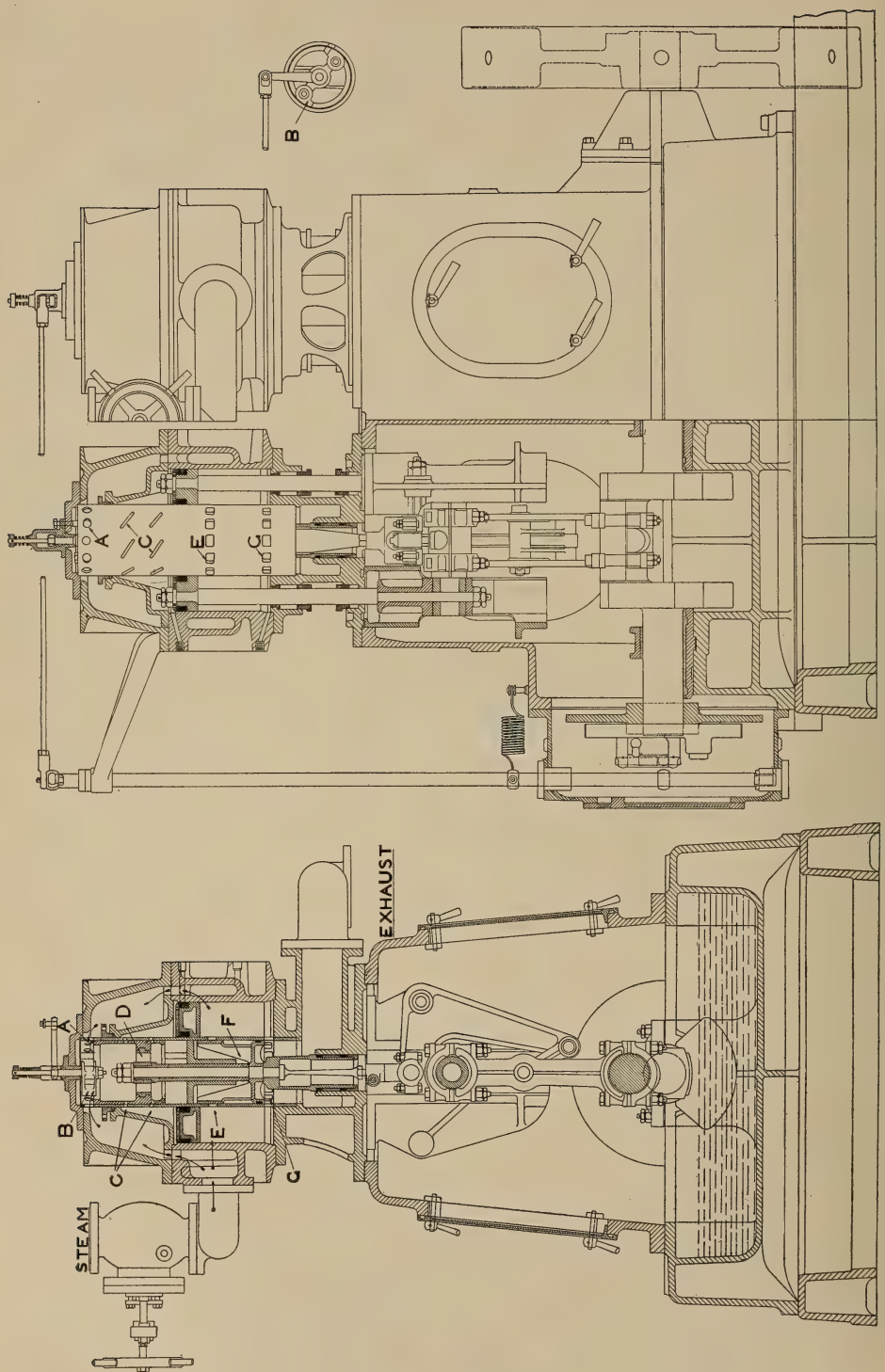


FIG. 24.—A TWO-CRANK COMPOUND SCOTT ENGINE MADE BY MESSRS. REAVELL & CO., LTD., IPSWICH

to pass from above to below. The controlling cylinder is filled at this position with steam of pressure near that of high-pressure admission.

As the pistons fall the by-pass closes, and the steam expands as the volume between the pistons increases, to be compressed along the same curve during the up-stroke, any small loss by leakage being made up by fresh steam from the high-pressure cylinder. The steam in the controlling cylinder, acting downward on the difference of the piston's areas, forms a buffer more than sufficient to keep the parts in constant thrust on the crank-shaft. It will be observed that the work done by the steam under the low-pressure piston is absorbed in compressing steam in the controlling cylinder, which is given out again in the succeeding down-stroke, the engine being thus, as far as crank pressures are concerned, strictly single-acting. The rate of expansion in the controlling cylinder has nothing to do with the rate of expansion of the working steam, and may be varied quite independently of it.

The incoming steam plays upon the tubular-valve distance piece, through which low-pressure steam passes. This enables the engine to be worked with high superheat without the slightest trouble, for the superheat heats this distance-piece and the receiver-steam within it, before reaching the valve rings. As will be seen, there are no glands subjected to the action of high-pressure steam to give trouble, and no harm can arise from water in the cylinders, as the piston rings are held up to the piston faces by openings which give way and allow the rings to lift and pass any water encountered by the pistons. These rings are cut and sprung into the cylinder bores and thus do not suffer, as do solid rings, from distortion of the bores due to superheat. A table of results after four years' work in the case of two Peache engines now before us, shows no traces of leakage through pistons or piston-valves, testifying to the correctness of their principle and original accuracy of construction.

The engine shown in Fig. 23 developing 550 indicated horse-power, using saturated steam of 180 pounds pressure, and with a 26-inch vacuum, gave at full, $\frac{3}{4}$, $\frac{1}{2}$, and $\frac{1}{4}$ load, respectively, 16.05, 16.2, 17 and 18.6 pounds per indicated horse-power per hour; another and larger engine of 800 indicated horse-power working with the low pressure of 120 pounds saturated steam and 25-inch vacuum gave, respectively, 16.5, 17, 17.8 and 19.8 pounds per indicated horse-power per hour.

The economy effected by using superheated steam is considerable, being usually about 22 per cent. for 200 degrees F. above saturation, beyond which there is not much gain to be had. Thus, the two trials just quoted would give, with 200 degrees F. superheat, 12.5 and 12.85 pounds per indicated horse-power, respectively.

The Peache governor, acting upon a throttle-valve, works in an oil-tight case and is driven by two belts. It is usually adjusted to give a permanent variation of 3 per cent. between full and no load, and 2 per cent. between full and half load. These percentages are preserved throughout the wide range of 30 per cent. covered by the variable-speed device with which the governor is fitted.

The Peache engine is made in the following sizes:—

Non-Condensing.					Condensing.
$10\frac{1}{2}$x$17\frac{1}{2}$	350	revs.,	330	I.B. H. P.	$10\frac{1}{2}$x19
11					11
12x19	325	"	400	"	12x22
12					12
$13\frac{1}{2}$x$21\frac{3}{4}$	300	"	515	"	$13\frac{1}{2}$x24
13					13
15x24	280	"	600	"	15x27
14					14
16x26	260	"	725	"	16x29
15					15

THE SCOTT ENGINE

The Scott compound engine, built by Messrs. Reavell & Co., Ltd., of

Ipswich, is another highly interesting example of original and successful design. In principle it is a revival and development of the century-old Cornish steam cycle; in practice it is an absolutely up-to-date high-speed constant-thrust engine, adequately filling the exacting requirements of modern central station work.

The particular example illustrated in Fig. 24 is a two-crank engine, but as each crank is served by a complete and separate compound engine, the description will apply equally whether one, two, or three cranks be used. Structurally speaking, the Scott engine consists of a single cylinder of large diameter relatively to the stroke, mounted by the usual distance-piece upon a cast-iron crank-chamber or casing, the interior of which is subject to the splash system of lubrication.

Fixed centrally in the cylinder and extending for some distance above it, is an accurately turned and bored tube, called the valve liner. The piston is annular and is fitted with packing rings bearing against both cylindrical surfaces. There are, of course, two piston-rods, each with its own slide-block working between flat, parallel guides, the two blocks being united by a long cross-head pin. The whole space between the two slide-blocks is filled by the small end connecting-rod brasses.

The connecting-rod itself is in two parts, or, more correctly speaking, there are two separate connecting-rods, set a sufficient distance apart to admit of the bell-crank lever operating the central piston valve, to be got in between them. The hollow plunger-guide passes through the exhaust space, and is provided with metallic packing rings. The lower portion of the valve stem is formed into a broad flat steel spring, thus obviating any necessity for a pin, joint, or need of lubrication. The motion of the valve, derived from a point in the connecting-rod, can be easily followed, and it will be seen that the changes in its rate of movement are such as to give a sharp cut-off with a wide and sustained exhaust opening.

The steam entering through the stop-valve, passes up between the inner and outer walls and covers and is admitted into the valve liner through ports *A* near the top. About half way down the liner is a diaphragm or partition, through a long bush in which the stalk or stem of the piston-valve works freely, but without leakage. The upper half of the liner is thus constantly charged with steam at stop-valve pressure, which, by means of the diagonally-placed slots or ports *C*, is admitted to the space above the piston when the piston valve is in the position shown in the engravings, similar ports cut through the piston valve being then in correspondence. At an early point in the revolution, determined by the governor as explained later, cut-off occurs and the remainder of the stroke is performed by the expansion of steam as in any ordinary engine.

It is when the crank is turning the bottom center that the peculiarity of the Scott engine begins to show itself. At this period of the stroke the piston itself is nearly stationary, but the valve is rapidly moving (with the effect that ports *E* and *G* in the liner are uncovered simultaneously, opening up a communication between the upper and lower sides of the piston and thus transferring steam at equal pressure and temperature from the top to the bottom of the cylinder. This transfer continues for about half the up-stroke and is terminated first by the piston itself, which overruns the ports *E*, and then by the action of the piston valve *F*, which closes ports *E* and *G*.

The steam thus transferred to the under side of the piston then completes its second stage of expansion, and at the end of the upward stroke the exhaust valve opens and allows this steam to escape to the atmosphere or to the condenser.

In the meantime the steam which remained in the cylinder above the piston when the transfer closed, is

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compressed during the latter half of the upward stroke, the clearance space at the top end of the cylinder being so proportioned that the steam is compressed up to initial pressure at the end of the stroke. The cycle is completed by the opening of the valve *D* for the next stroke, the fresh steam thus admitted entering a space filled with steam at its own temperature and encountering surfaces already heated up to very nearly that amount. Thus initial condensation is avoided and the inertia of the reciprocating parts is entirely absorbed by the high compression, enabling the engine to be run at a high normal rate of speed without the use of a separate air-buffer arrangement.

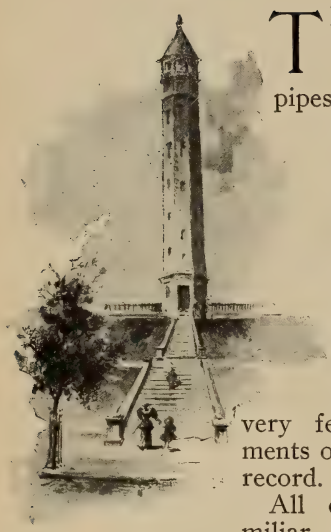
The upper piston valve *D*, though partaking of the reciprocating motion in common with the lower or transfer valve *F*, is yet capable of an independent movement under the control of the governor, namely, an axial rotation. The valve being provided with spiral or inclined ports corresponding to those seen in the valve liner at *C* needs only to be partially turned round to accelerate or delay the point of cut-off as desired, and this is effected in the simplest possible manner. The vertical spindle actuated by the shaft governor and seen in both views at the top of the cylinder and also in the small separate plan, carries at its lower end a cross-head or bridge *B* from which depend two guide-studs passing through holes in the valve *F*. Thus any movement of the bridge is communicated to the piston valve as it slides up and down, forming an automatic expansion gear identical in principle with the well-known Rider gear.

The makers claim for this engine an extremely low steam consumption based on the practical elimination of port clearance, the improved system of steam-jacketing, and the avoidance of wasteful drops in pressure and temperature of the incoming steam.

As will be noticed, the design of the cylinder entails very regular and symmetrical castings; there is therefore little distortion at high temperatures with superheated steam for which the engine is specially intended. We are able, at present, only to give the figures relating to saturated steam, which, though good in themselves, are considerably improved when superheated steam is used. Thus, a 100 kilowatt set working with saturated steam at 150 pounds pressure and a 26-inch vacuum showed a consumption at full load of 15.48 pounds per indicated horse-power and 27.7 per kilowatt. A similar set of 150-KW. capacity, also working with 150 pounds (saturated) steam pressure, but non-condensing, gave 19.12 pounds per indicated horse-power and 31.3 pounds per kilowatt. These figures will serve to show that the Scott engine, as manufactured by Messrs. Reavell, has passed beyond the stage of experiment and is entitled to take its place among the very few examples of original design which are competing successfully against the highest class of ordinary-type engines.

THE DISCHARGE OF WATER THROUGH STREET TAPS AND HOUSE SERVICE PIPES

By Wm. Paul Gerhard, C. E.



THE relative discharging capacities of water pipes were long ago made the subject of exhaustive studies, and a large and varied number of formulæ, tables and diagrams have been published as the result of the labours of leading hydraulic engineers; but only very few actual experiments of such flow are on record.

All engineers are familiar with the various methods of obtaining the amounts of water discharged through pipes of any given diameter and of given length. The writer has endeavoured to apply some of these methods to the problem of finding the discharge of water through service pipes or pipes of comparatively small diameter, which supply buildings with water from a street main. The amount of water used per capita per diem, has in American cities increased and is still increasing so enormously that water companies, both private and municipal, find themselves compelled to actually limit to the smallest capacity the size of the branch or "tap" which they allow to the individual water taker.

Some years ago, Mr. Herbert Shedd, C. E., of Providence, R. I., plotted a diagram, reproduced in "The Engineering Record," of November 7, 1891, from which to determine the size of the service pipe connections. The range of Mr. Shedd's diagram, however, is not sufficient for the purposes of the hydraulic engineer; neither is it clear from the published description just how the curves on his diagram were obtained.

The writer has, therefore, broadened the scope of the investigation, and by using formulæ which to him seemed the most rational for the circumstances of the problem, has calculated and plotted the curves shown in the double-page diagram accompanying this article. The values given in this are nearly identical with those of Mr. Shedd's diagram, as far as the latter go. The present curves were computed by Mr. A. E. Hansen, the writer's assistant engineer, and a graduate of the Massachusetts Institute of Technology. A brief explanation of the methods and of the formulæ adopted for the construction of the diagrams will be given first, and afterwards an example of their practical use and application.

The diagram, designated as Fig. 1, exhibits two classes of curves. Those shown in broken lines represent the discharge through service pipes with branches of same size, and without the use of taps reducing the areas, while the curves shown in full lines represent the discharge through pipes with areas reduced by and at the taps, the word "tap" signifying the immediate connection by special fittings between the service pipe and the street main, and assumed to be 18 inches long for these computations.

The first-named curves were calculated according to Prony's formula*

$$G = \left(\frac{(3d)^5 \times H}{L}\right)^{\frac{1}{2}} \times 1.20032$$

in which

G = U. S. gallons per minute,
d = diameter of pipe in inches,
L = length of pipe in yards,
H = head of water in feet.

In the large diagram, both head in feet and pressure in pounds per square inch are given, and the discharge can be read off both in gallons per hour and in cubic feet per minute, as may be found most convenient.

The second-named curves,—those giving the discharge through pipes with taps of reduced area,—were computed by adding the head lost in the service pipe and the head lost in the tap. The head lost in the service pipe is the same as in the previous case minus the head due to friction in a pipe of the same diameter and of the length of the tap. The head lost in the tap, however, is made up of three different factors:—First, the loss by friction in the pipe; second, the loss by friction at the entrance; third, the loss by friction in the stopcock, union, etc. There is another loss at the junction of the tap and service pipe, by the increase in area, but the change from the tap to the service pipe if made as it should be, with a long taper fitting, may be neglected.

While the friction in the service pipes was computed by Prony's formula, it seemed advisable, owing to the short length of the taps, to use for the friction in the tap a formula in which the variation in the ratio of d and L is not so marked as it is in Prony's, the formula used being as follows:—**

$$H_1 = f\left(\frac{L \times v^2}{d \times 2g},\right)$$

in which

H_1 = loss of head by friction in feet.
L = length of pipe in feet.
d = diameter in feet.
v = velocity of flow in feet per second.
g = 32.16.
f = friction coefficient as tabulated by Fanning, Smith, and others, and varying from 0.05 to 0.01.

The loss of head at the entrance was computed by the formula**

$$H_2 = m\frac{v^2}{2g},$$

in which m is the factor depending upon the projection of the tap into the street main and the condition of the projecting edges. For these calculations the value of m as 0.62 appears to the writer to be a proper one.

The loss of head by friction in the stopcock and other obstructing edges, such as unions, was assumed as 50 per cent. of the value of H_1 and depends very largely on the velocity of the water in the tap.

In the diagram, two lengths of service pipe were assumed and plotted, viz., 74 feet and 58 feet. These were selected in order to compare the results obtained in the diagram with those obtained by Herbert Shedd, who used these specific lengths, which seem to apply closely enough to the usual conditions. How the discharge for other lengths may be obtained is explained further on.

To illustrate the way in which the double-page diagram was constructed, assume that it is desired to find the head lost in a 1½-inch pipe with a 1-inch tap, the total length of service being 74 feet, for an hourly discharge of 4000 gallons.

The head lost by friction in 74 less 1½ or 72½ feet of 1½-inch pipe, according to Prony's formula, is 17.53 pounds.

The head lost by friction in 1½ feet of 1-inch pipe, according to the formula,

* See Box, on "Hydraulics."
** See Merriman's "Hydraulics."

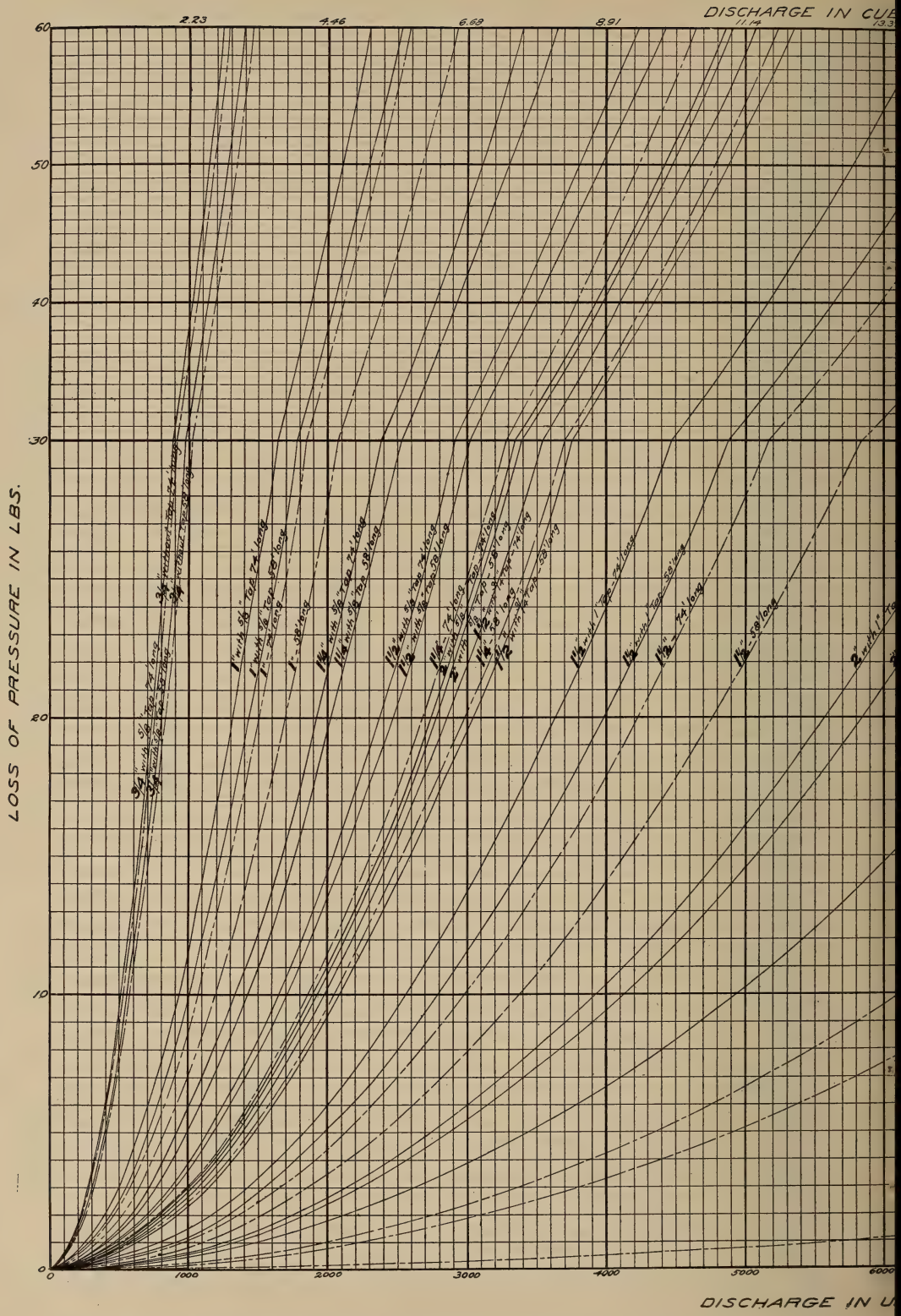
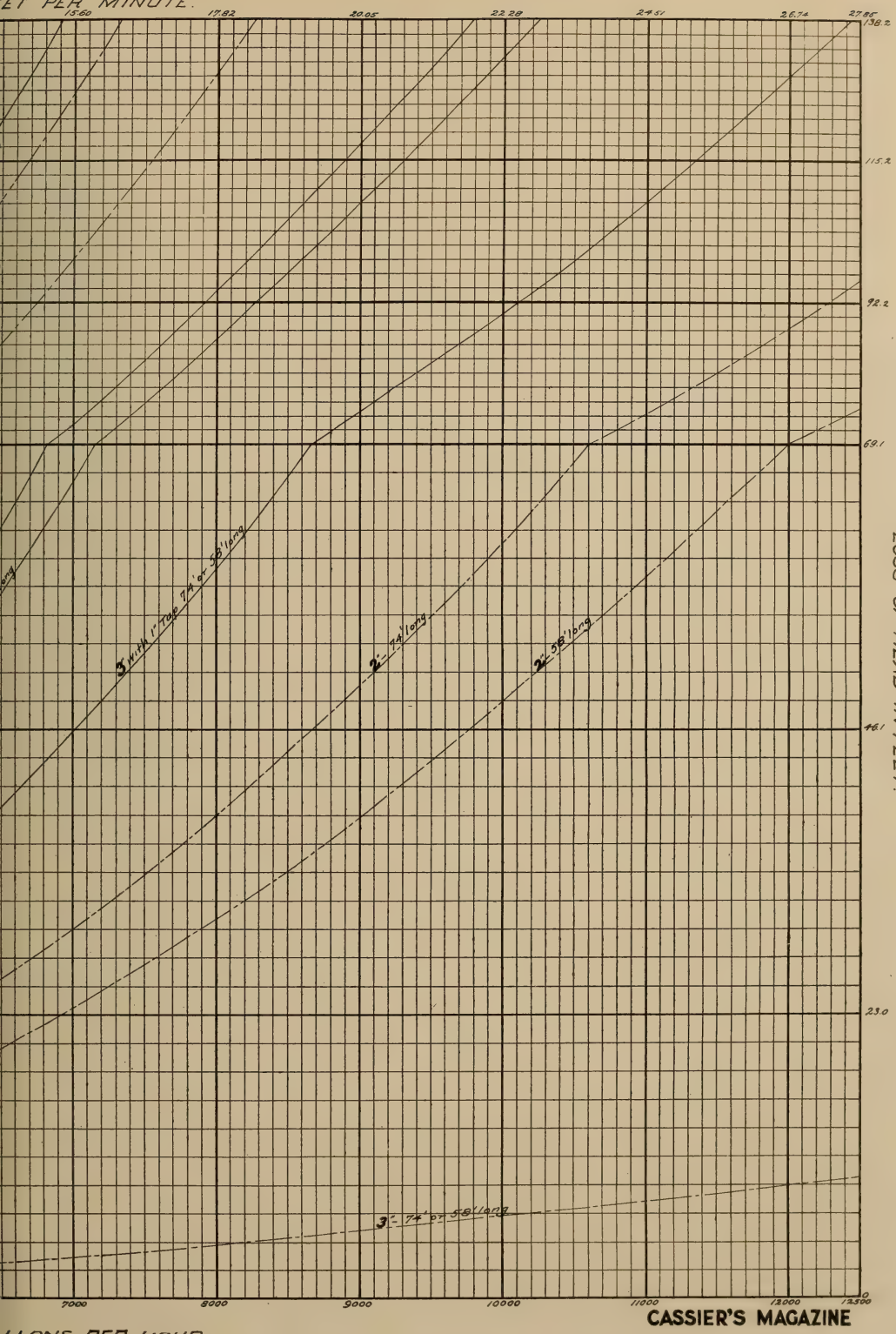


FIG. I.—CURVES SHOWING THE DISCHARGE THROUGH SERVICE PIPES, WITH AND WITHOUT THE USE OP TAPS, THE DISCHARGE UNDER THE



CASSIER'S MAGAZINE

THE FULL LINES REPRESENTING THE DISCHARGE UNDER THE FORMER CONDITIONS AND THE BROKEN LINES LATTER CONDITIONS

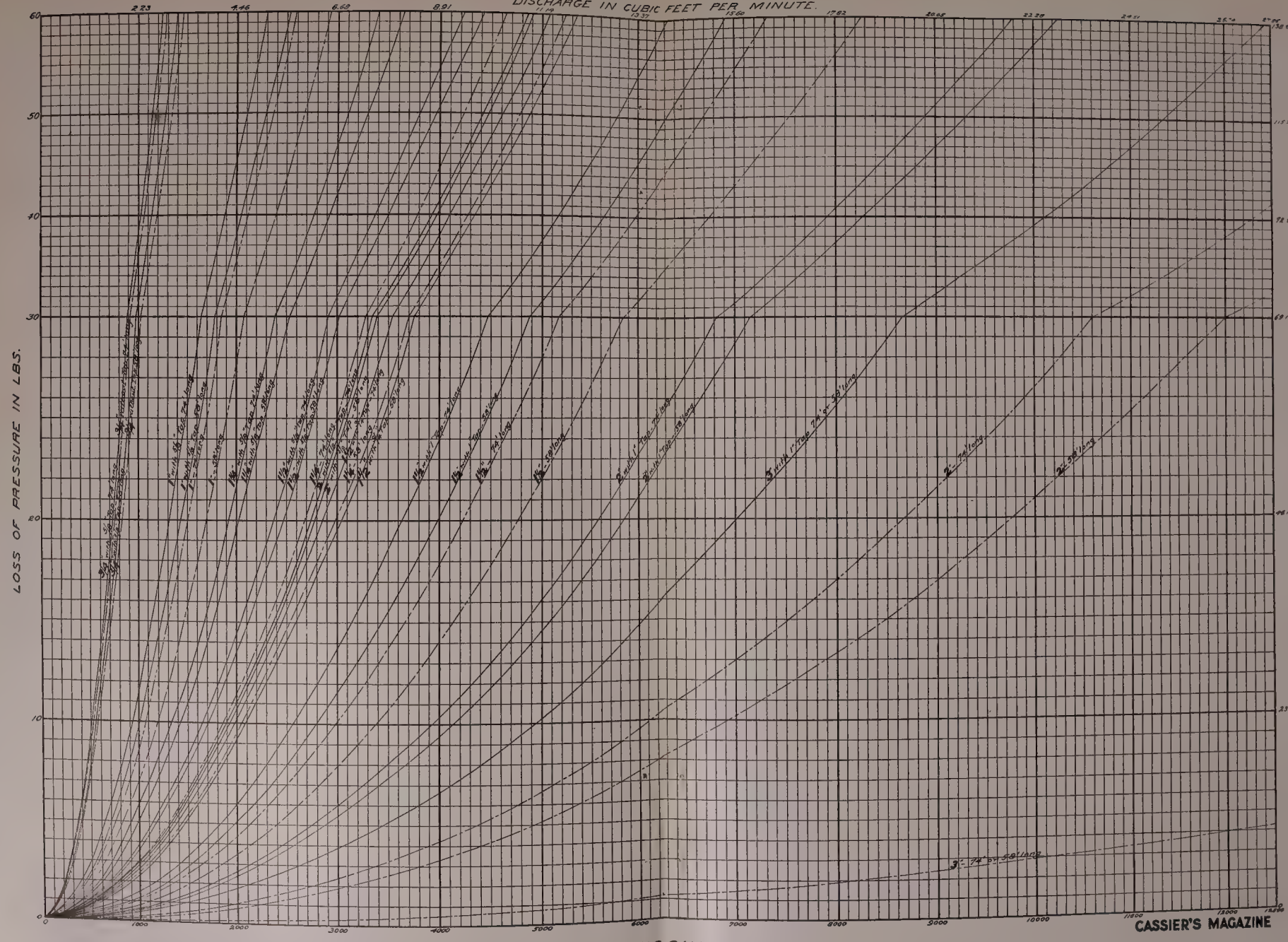

DISCHARGE IN CUBIC FEET PER MINUTE.
LOSS OF PRESSURE IN LBS.
LOSS OF HEAD IN FEET.
DISCHARGE IN U.S. GALLONS PER HOUR.
CASSIER'S MAGAZINE

FIG. I.—CURVES SHOWING THE DISCHARGE THROUGH SERVICE PIPES, WITH AND WITHOUT THE USE OP TAPS, THE DISCHARGE UNDER THE LATTER CONDITIONS THE FULL LINES REPRESENTING THE DISCHARGE UNDER THE FORMER CONDITIONS AND THE BROKEN LINES

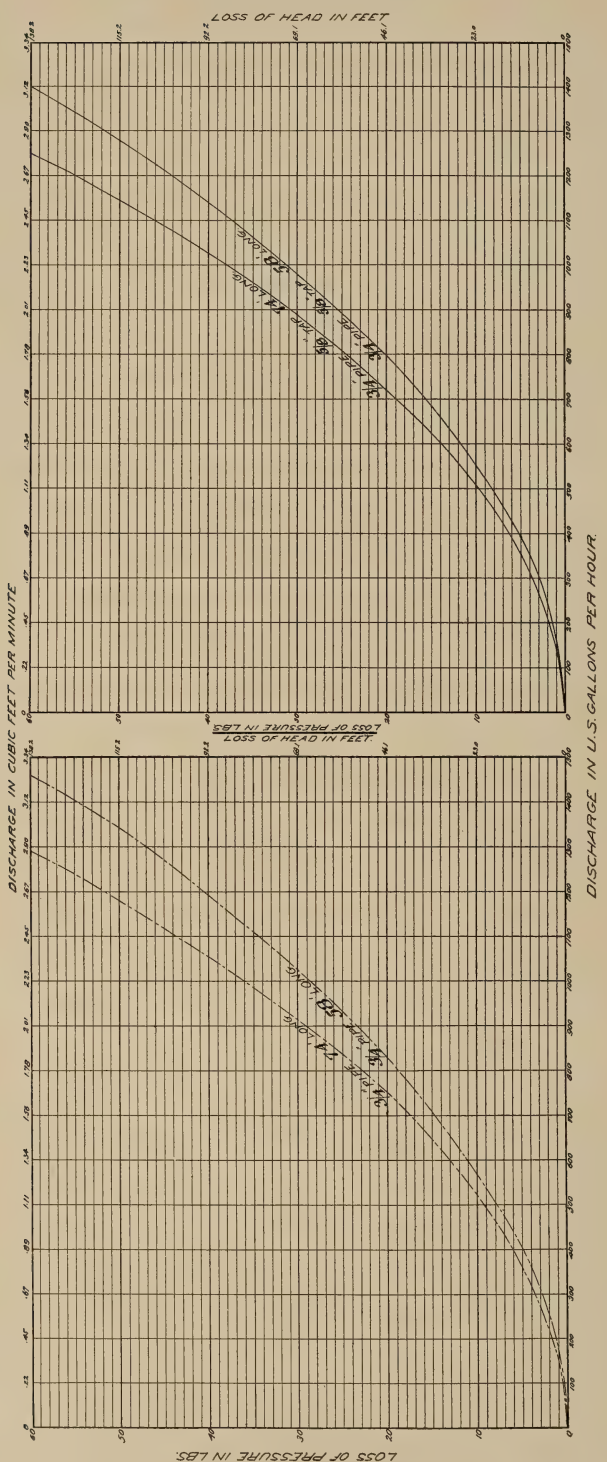

LOSS OF HEAD IN FEET.
DISCHARGE IN CUBIC FEET PER MINUTE.
LOSS OF PRESSURE IN LBS.
DISCHARGE IN U.S. GALLONS PER HOUR.
LOSS OF HEAD IN FEET.
LOSS OF PRESSURE IN LBS.

FIG. 2.—CURVES SHOWING, AT THE LEFT, THE PRESSURE LOST FOR VARYING DISCHARGES THROUGH ¾-INCH PIPES 74 AND 58 FEET LONG, RESPECTIVELY, AND AT THE RIGHT, THE PRESSURE LOST THROUGH ¾-INCH PIPES WITH ⅝-INCH TAPS OF THE SAME TOTAL LENGTHS

$$H_1 = f \frac{L \times v^2}{d \times 2g},$$

with a value of $f = 0.024$, is 2.24 pounds.

The head lost at entrance, according to the formula

$$H_2 = m \frac{v^2}{2g},$$

is equal to 3.08 pounds,

The head lost by friction due to stopcock, etc., is $H_3 = 50$ per cent. H_1, equal to 1.12 pounds.

Then the total head lost is equal to 23.97 pounds.

This value may be plotted on the diagram as one point of the discharge curve for a $1\frac{1}{2}$-inch service pipe with 1-inch tap of a total length of 74 feet, by marking the point of intersection of the co-ordinates which indicate 4000 gallons discharge and 23.97 pounds pressure.

Any number of points may be found and plotted in a similar way for the same pipe and tap, but for varying discharges. The line connecting these points will then be the curve which indicates the loss of head for a given discharge, or vice versa.

All curves on the diagram which refer to service pipes with taps, were obtained, as illustrated in the above example.

Fig. 2 on page 26 shows on its left half in a more legible scale the head or pressure lost for varying discharges through $\frac{3}{4}$-inch full-sized pipes, 74 and 58 feet long respectively; and on its right half in the same manner for $\frac{3}{4}$-inch pipes with $\frac{5}{8}$-inch taps of the same total lengths. These curves were obtained in the same way as those in the large diagram, and it is unnecessary to dwell upon them at greater length, the object of the diagram being merely greater clearness.

Fig. 3 on page 29 is to be used in connection with the others, when it is desired to find discharges of pipes of other lengths than 74 or 58 feet. The broken curve on this diagram shows the percentage of discharge for full-sized pipes without taps, while the other two full curves show the percentage for a $1\frac{1}{2}$-inch pipe with 1-inch tap and a $1\frac{1}{4}$-inch pipe with $\frac{5}{8}$-inch tap, respectively, for lengths of pipe varying from 20 to 1000 feet. It should be clearly understood that the percentage of discharge on Fig. 3 refers to discharges of 74-feet long pipes, and not to 58-feet long pipes on Figs. 1 and 2.

It is an easy matter to figure the percentage of discharge through full-sized pipes since, according to Prony's formula, the discharge for different lengths of pipe varies inversely as the square root of the lengths.

In the case of the pipes with taps, this becomes, however, more difficult, because the friction in the smaller tap varies at a different ratio than it does in the larger service pipe. The method employed by the writer was the actual calculation for varying lengths of service pipe, the length of tap remaining the same. These calculations showed that the curves drawn are correct within 1 per cent.

Suppose, for instance, it is desired to find the percentage of discharge through a $1\frac{1}{2}$-inch pipe with a 1-inch tap, 570 feet long, as compared with that through a $1\frac{1}{2}$-inch pipe with 1-inch tap, 74 feet long. Referring to Fig. 1, under the line of pressure equal to 30 pounds, a $1\frac{1}{2}$-inch pipe with 1-inch tap, 74 feet long, delivers 4460 gallons per hour. A full-sized $1\frac{1}{2}$-inch pipe of the same length without tap, for the same delivery uses 22.4 pounds pressure, so that the difference, or 7.6 pounds pressure, is used up by the tap. By increasing the length of pipe, we decrease the delivery, and by decreasing the delivery, we decrease the friction in the tap, which, let us say, for instance, will be 1.4 instead of 7.6 pounds when the service pipe is increased to 570 feet. Subtracting 1.4 from 30 pounds gives us an available pressure of 28.6 pounds at the tap end

of the service pipe, and, from Fig. 1, a discharge of 5050 gallons for a full-sized 1½-inch pipe 74 feet long.

Referring now to Fig. 3, a full-sized pipe of any diameter and 570 feet long discharges 36 per cent. of the water delivered by the same size pipe 74 feet long, that is, 5050 × 0.36 = 1818 gallons.

This represents the amount actually delivered by a 1½-inch pipe 570 feet long, with a 1-inch tap, provided the assumption of 1.4 pounds pressure used up by this quantity of water in passing through a 1-inch tap is a correct one.

This can be verified by the aid of Fig. 1. For 1818 gallons a 1½-inch pipe, 74 feet long, uses 3.6 pounds pressure, and a 1½-inch pipe of the same length with a 1-inch tap uses 5.0 pounds pressure, which means that the difference, 1.4 pounds, is used up by the water in passing through the 1-inch tap. Therefore, the loss of pressure assumed by us proves to be the correct one.

To obtain the percentage of discharge we divide 1818 × 100 by 4460, which gives us a percentage of 40.7.

We may repeat this same process for the same length of pipe, 570 feet, but with different pressures, say, 10, 20, 30, 40, 50, and 60 pounds pressure, in order to find the average percentage at these pressures.

We then obtain the following:—

	Per Cent.
For 10 pounds pressure	40.6
For 20 pounds pressure	41.0
For 30 pounds pressure	40.7
For 40 pounds pressure	40.7
For 50 pounds pressure	40.7
For 60 pounds pressure	40.7

giving an average of 40.7 per cent. The possible limit of error is, therefore, in this instance only three-tenths of 1 per cent.

Owing to the large amount of work involved in plotting these curves, the only two shown in Fig. 3 are those for 1½-inch pipe with 1-inch tap, and for 1¼-inch pipe with ⅝-inch tap, but from the foregoing explanations it is possible to construct similar percentage curves for any other discharge curve plotted in Figs. 1 and 2, having a tap of decreased area.

The percentage curve for full-sized pipes on Fig. 3 refers to any full-sized pipe 74 feet long on Figs. 1 and 2.

The following problem will illustrate the practical use of the diagrams:—A building is to be supplied with water. The point at which the pipe enters the building is on the same level as the water main in the street. The pressure in the water main is found to be 35 pounds and the distance from this main to the building is 180 feet. We are to deliver 2500 gallons per hour into the building, under a pressure at the building line of 15 pounds. Shall we use one 1¼-inch full-sized pipe, two 1-inch full-sized pipes, two 1¼-inch pipes with ⅝-inch taps, or finally one 1½-inch pipe with 1-inch tap?

In the pipe line from the main to the building we may use up 35 — 15 = 20 pounds pressure. Referring to Fig. 1,—

	Gallons
One 1¼-inch pipe, 74 feet long, 20 pounds pressure, discharges	2,680
Two 1-inch pipes, 74 feet long, same pressure, discharge	3,000
Two 1¼-inch pipes, same length and pressure, discharge with ⅝-inch taps	3,840
One 1½-inch pipe, same length, with 1-inch tap, discharges	3,630

Referring to Fig. 3, the percentage of discharge through full-sized pipes 180 feet long, as compared to the 74-foot length, is 64 per cent.

The percentage, in like manner, for 1¼-inch pipe, 180 feet long, with ⅝-inch tap, is 75 per cent. That for 1½-inch pipe, 180 feet long, with 1-inch tap, is 69.4 per cent. Therefore,—

	Gallons
One 1¼-inch pipe, 180 feet long, 20 pounds pressure, discharges 2,680 x 0.64	1,715
Two 1-inch pipes, same conditions, discharge together, 3,000 x 0.64	1,920
Two 1¼-inch pipes, same conditions, but with ⅝-inch taps, together, 3,840 x 0.75	2,880
One 1½-inch pipe, same conditions, but with 1-inch tap, discharges 3,630 x 0.694	2,519

The choice, therefore, would of necessity be for a 1½-inch pipe, with a 1-inch tap, this being the combination giving the nearest to the desired result, and being, at the same

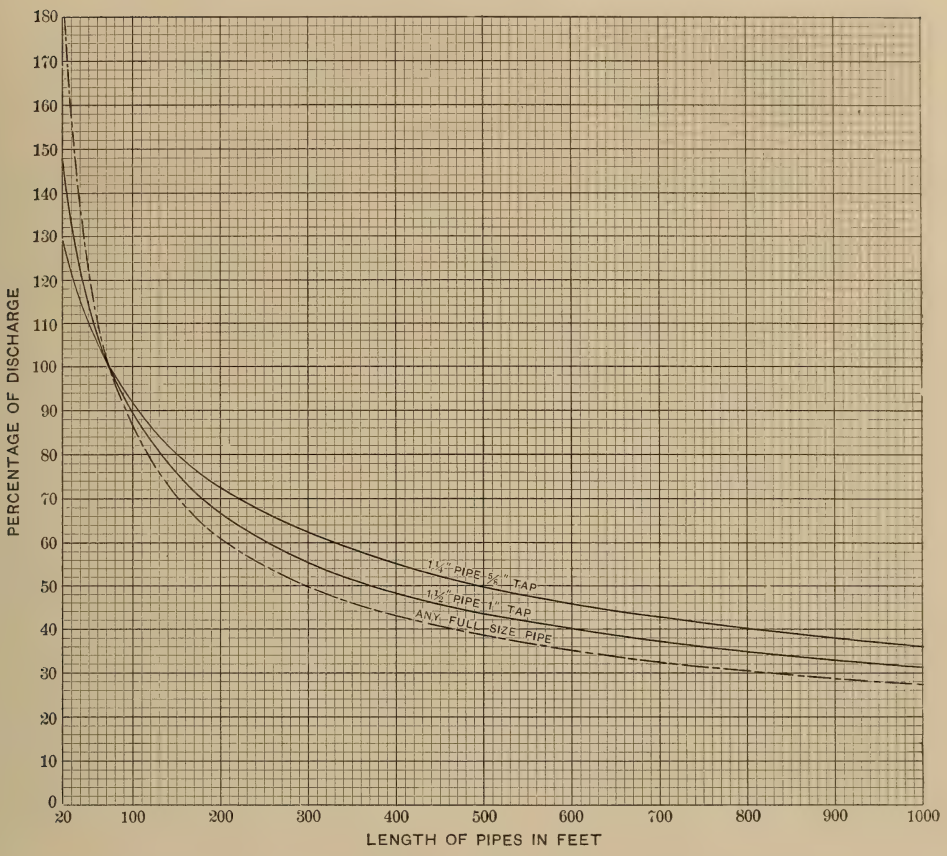


FIG. 3.—CURVES TO BE USED IN CONNECTION WITH THOSE PREVIOUSLY GIVEN WHEN IT IS DESIRED TO FIND DISCHARGES OF PIPES OF OTHER LENGTHS THAN 74 OR 58 FEET

time, the least expensive one to install.

In conclusion, it is interesting to make a comparison of the values as obtained by the use of the diagram, both with values recorded from actual experiments, and with values as given in other up-to-date theoretical tables.

Stephen H. Babcock, C. E., of Amsterdam, N. Y., made some actual experiments of the delivery of service pipes, ½ inch, ⅝ inch, and ¾ inch in diameter. The discharge of a ¾-inch pipe, 100 feet long, under 110 feet head, according to Figs. 2 and 3, is 23,895 gallons per 24 hours, while according to Mr. Babcock's experiment, it is 24,480 gallons; that is to say, the value given by the diagram is only 2.4 per cent. smaller than that obtained from actual experiments on the flow of water through service pipes,—a slight difference indeed when one considers that the conditions regarding interior pipe surfaces may vary.

J. T. Fanning, in his report of 1874 as chief engineer of the Manchester, N. H., waterworks, records the results of some experiments made to determine the flow of water under different pressures through various lengths of 1-inch wrought iron service pipe which had been in use one week at the time of the experiments.

He obtained, for example, through this 1-inch pipe, 774 feet long, with a pressure of 43 pounds, a discharge

of 1.5864 cubic feet per minute. For the same conditions Figs. 1 and 3 give a discharge of 1.5401 cubic feet per minute, the difference between the two results being only 2.9 per cent.

Messrs. Williams and Hazen have published in their book* tables showing the loss of head due to the friction of water in pipes 1000 feet long. The discharge of a $1\frac{1}{2}$-inch pipe, 1000 feet long, under 110 feet head, and of a $\frac{3}{4}$-inch pipe of the same length under 105 feet head, according to Figs. 1 and 3, is 42,928 and 7398 gallons, respectively, while the tables of Williams and Hazen make the values 43,200 and 7200 gallons, respectively (for ordinary iron pipes). The values for the $\frac{3}{4}$-inch pipe agree, therefore, within 2.7 per cent., while those for the $1\frac{1}{2}$-inch pipe agree within 0.7 per cent.

The close agreement of the values obtained by the use of the diagrams with those from actual experiments and from published tables, indicate that the diagrams here produced are reliable, and accurate for all practical purposes. At the same time, the user should always bear in mind that varying conditions of the interior surfaces of the pipes, varying degrees of uniformity of bore, varying number of bends and other changeable factors, influence the discharge of water through service pipes.

* Hydraulic Tables, Showing the Loss of Head Due to the Friction of Water Flowing in Pipes, Aqueducts, Sewers, etc., and the Discharge Over Weirs. John Wiley & Sons, publishers, 1905.

LOCOMOTIVE CRANES AS LABOUR SAVERS

By Lewis Glasgow Howlett

FIG. 1.—COALING A LOCOMOTIVE TENDER WITH A CRANE MADE BY THE BROWN HOISTING MACHINERY CO., CLEVELAND, OHIO

IMPROVEMENT in design and increase in the capacity of locomotive cranes have been pronounced and rapid in the past few years, so much so that the crane which carried off the gold medal at the Chicago Exposition in 1893 is today hopelessly obsolete,—a curiosity.

Since locomotive cranes are a specialty to the manufacture of which some builders are devoting their entire energy, the result has been standardization in sizes and types until now cranes can be turned out in quantities with the same economy of production from standardization that is secured in building machine tools or steam engines.

The design of locomotive cranes has been influenced quite as much by the progress of other industries as by any special effort to develop the

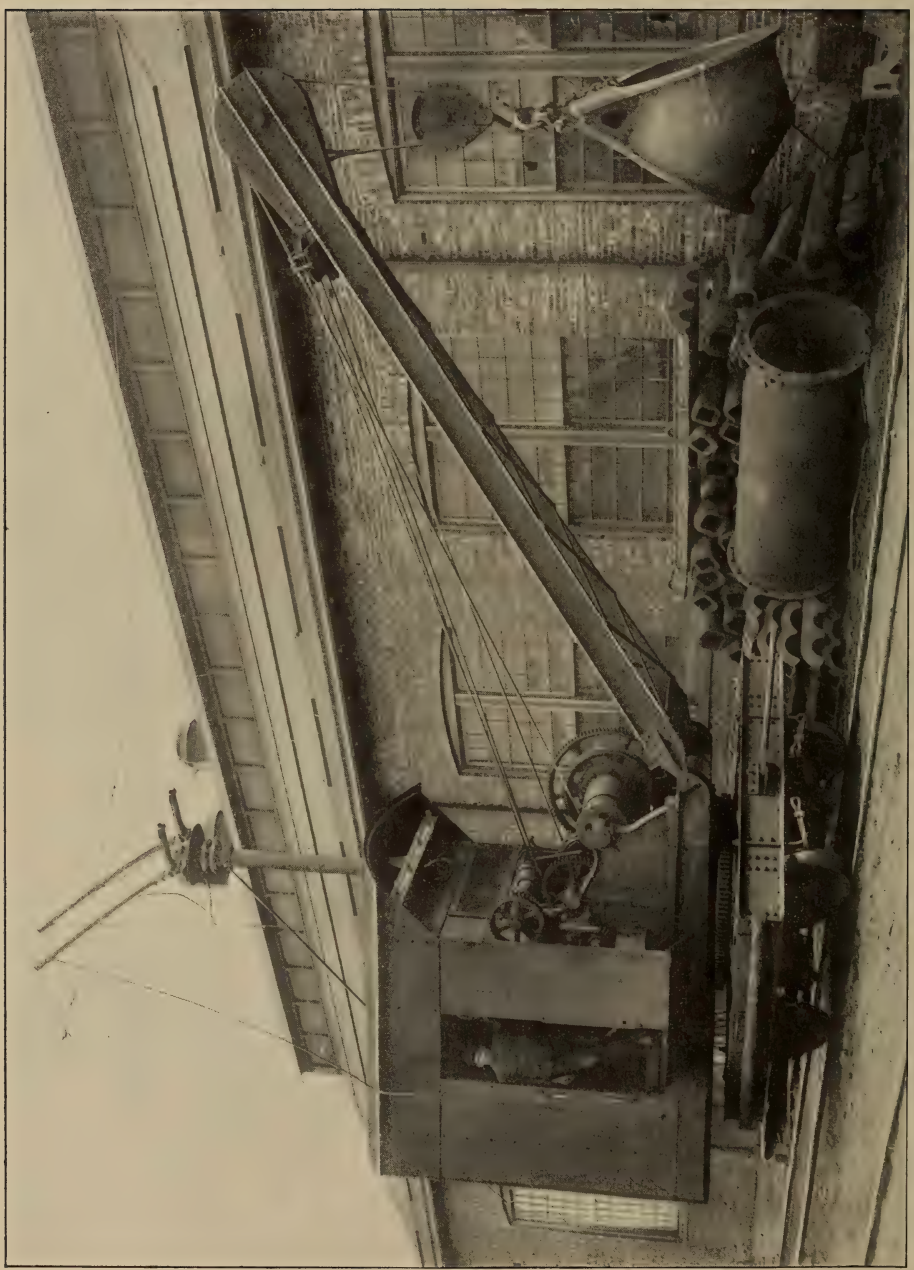


FIG. 2.—A 10-TON ELECTRIC LOCOMOTIVE CRANE MADE BY THE BROWN HOISTING MACHINERY CO., CLEVELAND, OHIO

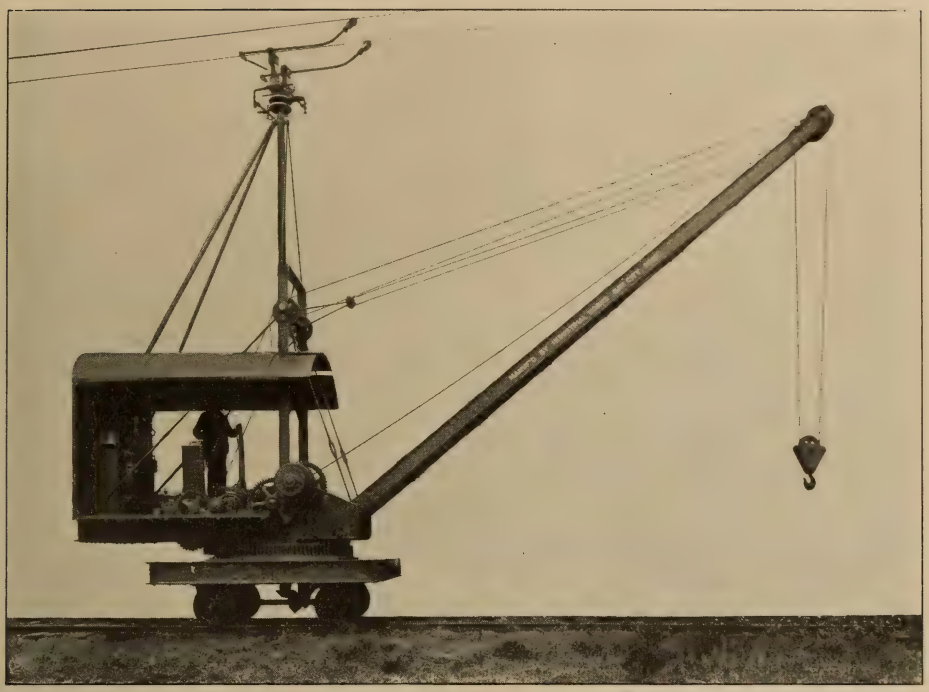


FIG. 3.—A 5-TON ELECTRIC CRANE WORKED BY A 50-H.P. DIRECT-CURRENT MOTOR. BUILT BY THE INDUSTRIAL WORKS, BAY CITY, MICHIGAN

crane. Loading and unloading of loose material, such as coal, gravel and ore, brought out the type known as the bucket crane; the lumber industry called for cranes with electricity and compressed air as motive power, reducing thus the danger from fire; while the general use of cranes for hauling purposes led to many improved designs in propulsion.

Locomotive cranes may be operated with either steam, electricity, or compressed air. Although electricity has been more generally adapted to electric travelers and large wharf cranes, its use in connection with locomotive cranes is very convenient in some classes of work. The specialization of motors, controllers, and brakes for crane service has added much to the simplicity and efficiency of electric motive power. Solenoid brakes, made to act automatically, reduce both the work of the operator and the liability to accident.

Either system of electric transmission is now used. Alternating-current three-phase motors have been perfected so that a large starting torque is obtainable as in the series-wound direct-current motor. The ability of the three-phase motor to withstand a large percentage of overload and the absence of commutator troubles have much in their favour for a hoisting motor.

There are many places where electricity can be used in locomotive cranes when steam would be objectionable. Electric cranes operating in lumber yards, on wharves, or around warehouses, offer safe substitutes for steam boilers, which always carry a fire menace with them. In cases where a crane is used at infrequent intervals, the electric crane too is advantageous; it is always ready and uses up power only when at work. Electric magnets for unloading plates, billets, and even pig iron, can further be conveniently arranged on an electric crane.

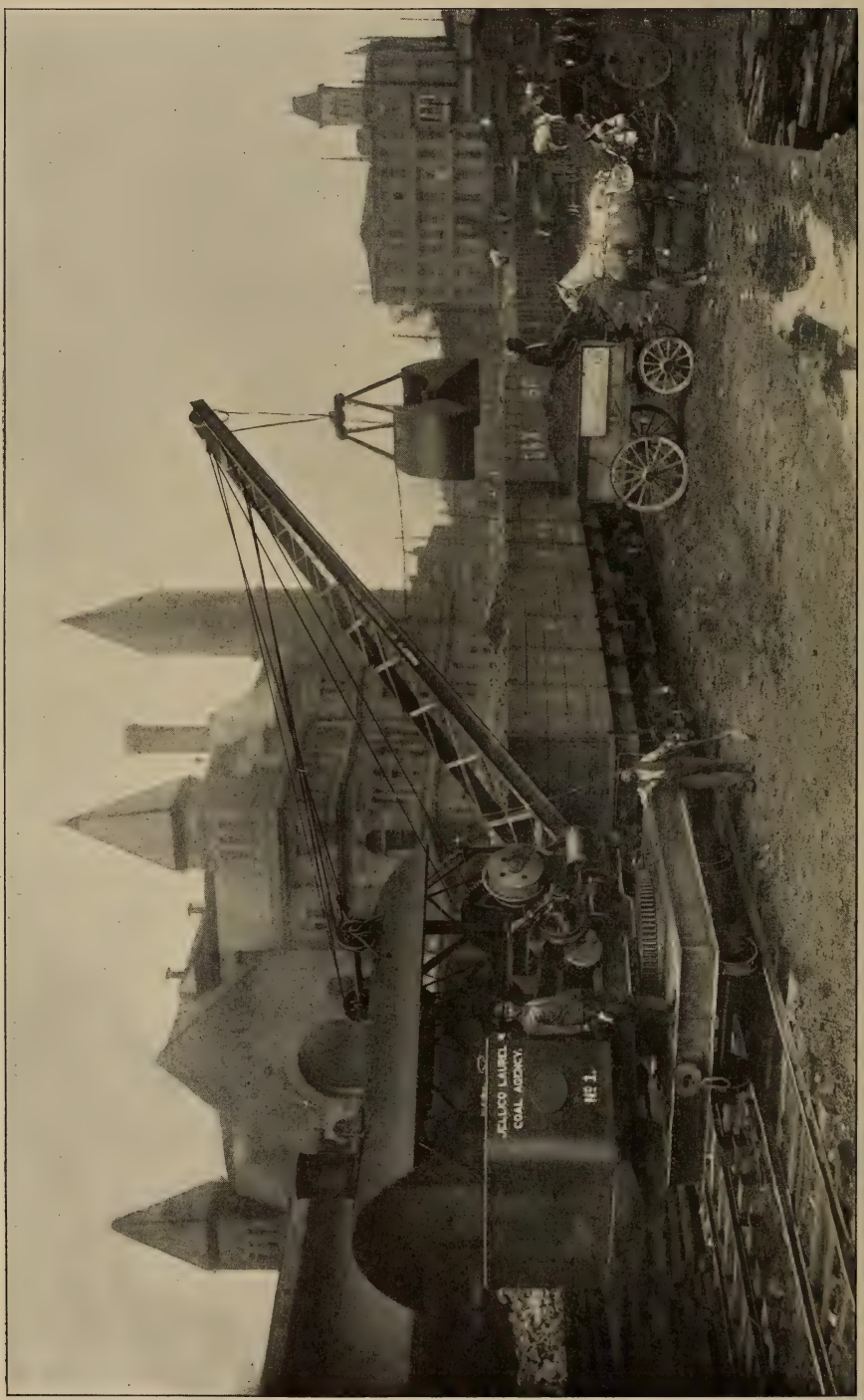


FIG. 4.—A GRAB BUCKET CRANE BUILT BY THE INDUSTRIAL WORKS, BAY CITY, MICHIGAN, LOADING A WAGON FROM A COAL CAR

FIG. 5.—WORKING IN IRON ORE WITH A LOCOMOTIVE CRANE SHOVEL

FIG. 6.—LOCOMOTIVE CRANE ON A STEEL TRESTLE SUPPLYING COAL TO THE WASHINGTON, D. C., NAVY YARD POWER HOUSE. BUILT BY THE BROWNING ENGINEERING CO., CLEVELAND, OHIO

A locomotive crane makes a very flexible locomotive coaling plant. Cars or locomotives need not be brought to one place for unloading or coaling, as the crane is capable of moving from place to place and hauling cars if occasion demands it. Several handlings of coal and ashes are avoided, as the coal is transferred directly from the car into the engine tender. The coal is handled by a clam-shell bucket of special construction for operating in the bottom of gondola cars, and removes about 90 per cent of the coal in the car. All of the motions of hoisting, slewing, traveling, and opening and closing the buckets are under the control of the operator. Many railways have installed locomotive cranes with grab buckets for unloading cars of coal. Some of them place the coal in storage bins and fill locomotive tenders through chutes, while others use them to coal directly from a gondola car.

Fig. 1 shows a crane, equipped with a 54 cubic feet bucket, coaling a locomotive tender directly from a car standing on a track parallel to the one on which the crane stands. As operated on one line of railway, this crane is capable of making over 50 trips per hour, handling from a ton to a ton and a half of coal at each trip. On such an equipment but two men are required,—one to operate the crane, the other, a labourer, to guide the bucket in the car. From statistics of various plants the average cost is made up as follows:—

Operator and helper, per day	$5.00
Coal	1.50
Oil	.50
Cost of maintenance	1.00
Total cost of handling 500 tons per day.	$8.00

This is equivalent to 1.6 cents per ton.

It is evident that in this system of handling coal and ashes there are many advantages that demand the attention of engineers. The first cost of such an installation is small as compared with former plants. No

space or ground need be prepared other than the usual tracks in the yard, and these are quickly installed. The outfit is portable and moves easily from one place to another, accommodating existing conditions. Coal is handled directly with no intermediate operations. Cranes may be used to handle other material and do other service if time permits.

A locomotive crane is an efficient appliance for handling coal and ashes in a power plant. Fig. 6 shows a crane with auto-grab bucket placed on an elevated railway running parallel with the power house of the Navy Yard at Washington, D. C. The elevated railway or trestle runs between a dock on the river front and the boiler house. Two hoppers, one at each end, are connected with the trestle. On top of the trestle runs the crane.

When the coal arrives in barges it is unloaded into the hopper car by the crane and the grab bucket, and as soon as the car is filled it is pushed by the locomotive crane to the upper end of the power house. The load is there charged through the bottom into the bin, goes from the bin through the crusher, and is from there elevated and conveyed by a link-belt arrangement to the various storage points.

The main storage pile is located beside the trestle and next to the hopper, and after the stoker bins are filled the coal is dumped from the car into this storage pile and from there later on reloaded by means of the locomotive crane and grab bucket into the hopper, from where it goes to the crusher. It is the same way when the coal arrives by rail, the only difference being that the locomotive crane, instead of taking the coal out from the barges, takes it out from the gondola cars by means of the grab bucket, placing it either in the bottom dumping car on the trestle or direct on the storage pile.

The method for disposing of the cinders and ashes is identical, but reversed. The ashes are gathered and elevated from the boiler room to the top of the building by link-belt conveyors and are then automatically

FIG. 7.—ANOTHER CRANE BUILT BY THE BROWNING ENGINEERING CO., HANDLING LOGS IN A LUMBER YARD

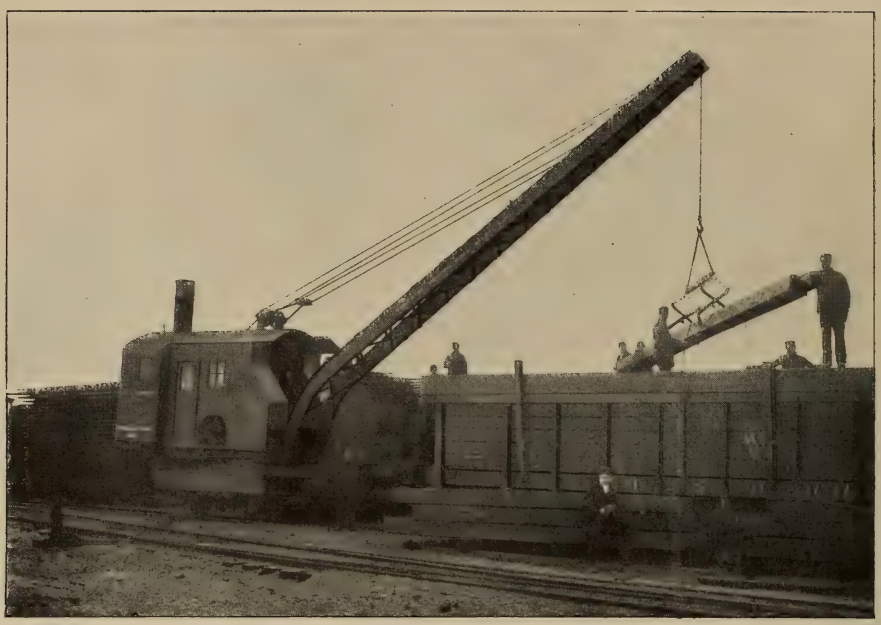


FIG. 8.—PILING LUMBER WITH A CRANE BUILT BY THE INDUSTRIAL WORKS

dumped in either one of two spouts. One of these spouts runs direct into a receiving hopper built underneath the trestle, and from which the ashes are dumped into railway cars. When the ashes have to be shipped by boat, the second spout is used, which conveys the ashes by gravity direct into the bottom dumping car on the trestle, and when this car is filled it is hauled by the locomotive crane down to the end of the dock where the receiving hopper is located and into which the ashes are dumped. A chute leads direct from the bin into the barges.

In large lumber yards locomotive cranes are doing the work formerly done by many men in loading, sorting, and piling lumber. It is estimated that lumber can be handled with a crane for about 15 cents per 1000 feet. Figs. 7 and 8, illustrating cranes working in lumber yards, show the special equipment applied for this industry, notably the long boom curved at the bottom to give greater clearance under the boom. Double timber hooks are used for handling long timber. These hooks are on a single run of rope giving a hoisting speed of about 125 feet per minute. Compressed air has been used as motive power on locomotive cranes in a few instances and there is no reason why it should not be used more universally, as it has all the good features of electric power and many advantages over steam. The air is stored in one or two tanks of small diameter at a pressure of 800 pounds per square inch, and the cranes are capable of running continuously from three to five hours. The tanks can be charged in from one to two minutes.

With two or more charging stations, a compressed air crane has as large a radius of action as a steam crane. It is especially adapted to use where sparks would be dangerous, and has not the hindrances of electric cranes due to overhead trolley wires. With the high pressure used, the difficulty of freezing exhaust pipes is eliminated, as in the process of compression practically all the moisture is squeezed from the air and deposited in tanks from which it can be drawn

off. A reducing valve is used to bring the pressure within ordinary working limits before it reaches the cylinders. Compared with other motive powers, compressed air is cleaner, simpler, and more convenient and should make an ideal power for a locomotive crane.

Fig. 5 shows a locomotive crane shovel which has the general appearance of a 20-ton crane mounted on a four-wheel car. The jib, however, is supplied with a shovel operated by a cylinder hung in trunnions similar to the arrangement so universally used on an excavator. The machinery of the ordinary shovel works only on an arc of 180 degrees. The shovel can be removed and the machine used as a locomotive crane. This machine has been found especially useful in digging ore where the grab bucket would not penetrate.

A self-propelling wrecking crane can be classed under the heading of locomotive cranes. The self-propelling feature has been added to wrecking cranes of capacities up to 100 tons. Two methods have been employed in adding the propelling mechanism on cranes of capacities from 40 to 100 tons. One arrangement

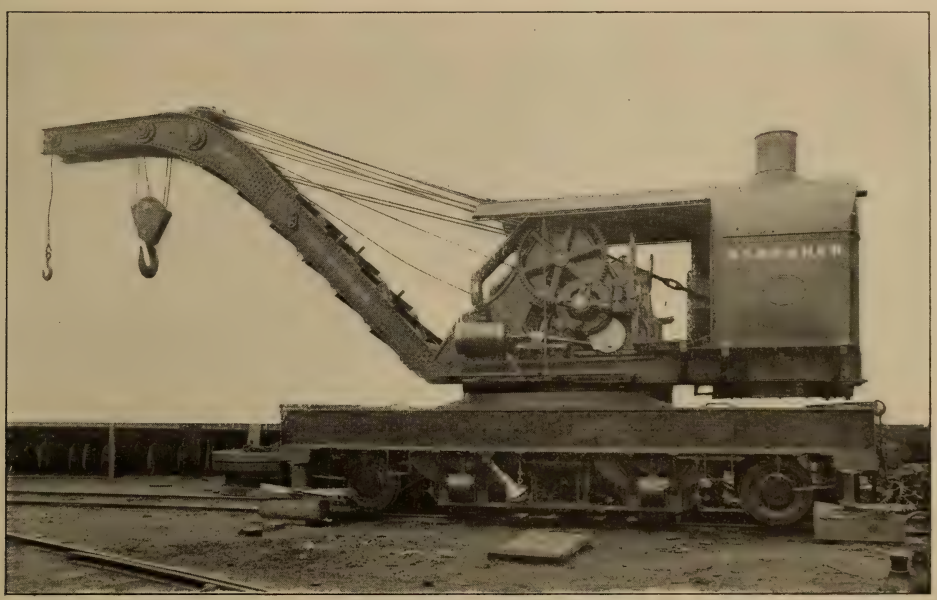


FIG. 9.—A 75-TON SELF-PROPELLING WRECKING CRANE ARRANGED WITH BOGIE TRUCKS. BUILT BY THE INDUSTRIAL WORKS

this crane, with the boiler and water tank placed so as to act as counterweights, is supported upon four rollers which can roll a complete circle on the bedplate of the car.

With this arrangement the machine is more flexible in its operation and has more advantages than an ordinary excavator. Being able to swing a complete circle, it can excavate material ahead or on either side and deposit it at any point, while places the two center axles in pedestal jaws arranged with semi-elliptical leaf springs. The axles are driven through spur and bevel gearing from engines above the car. A bogie truck axle is placed on each end of the car, serving as guiding wheels and distributing the weight over a greater number of wheels. For rapid transportation over the road the gearing under the car directly connected with the axle gear is disengaged by

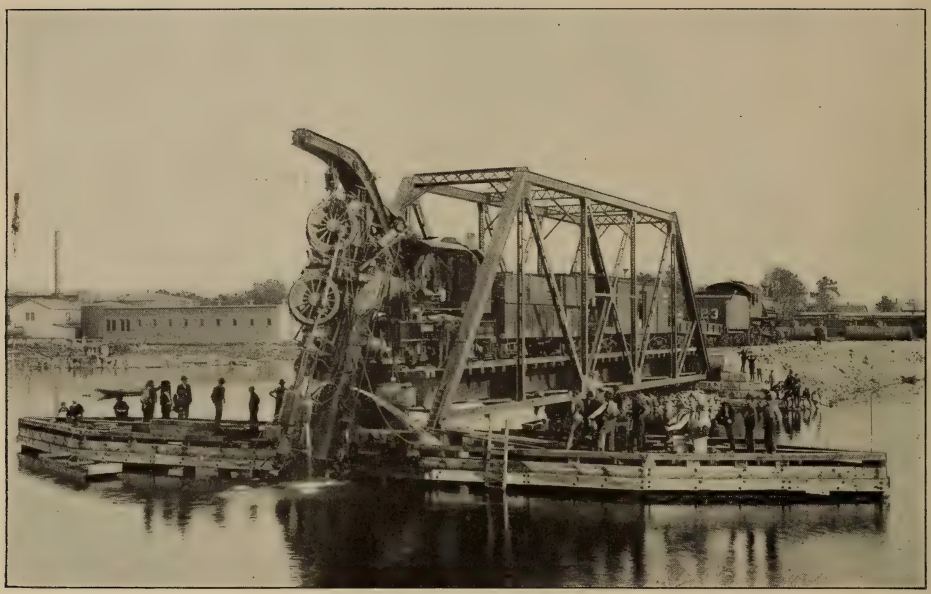


FIG. 10.—A 60-TON CRANE LIFTING A LOCOMOTIVE FROM A RIVER

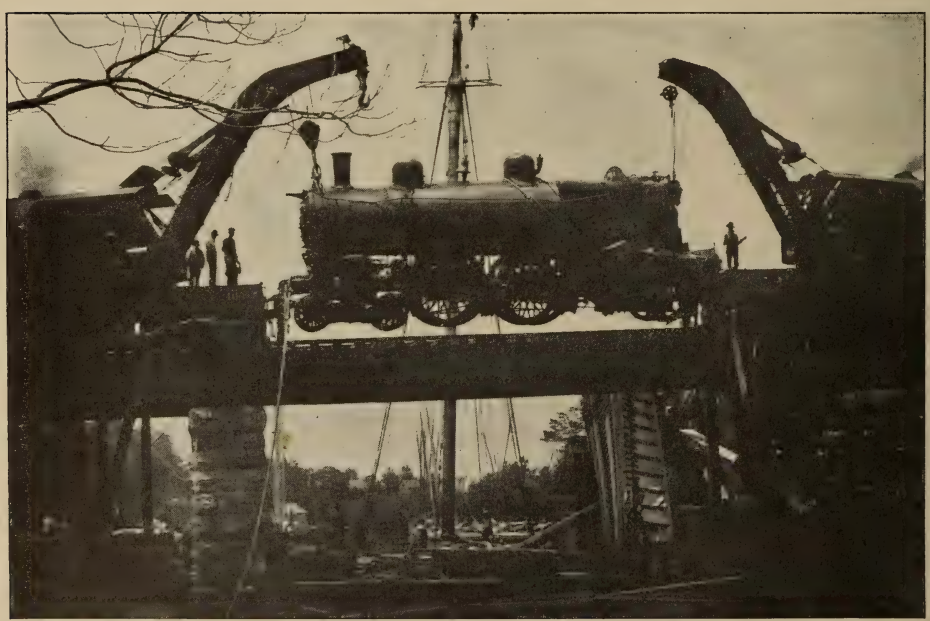


FIG. 11.—TWO 60-TON WRECKING CRANES AT WORK

a hand lever. The second method of arrangement is to place the two driving axles in rigid pedestal jaws on one end of the car and a standard truck on the other end.

This provides a better arrangement of running gearing for rapid transportation, but does not give as good a distribution of weight upon the driving wheels as the former method. The latter is employed where it is necessary to move the crane only, while the former gives greater propelling power and renders the crane of service in hauling many loaded cars in addition to propelling itself.

Since wrecking cranes have been transformed into locomotive cranes, it may not be uninteresting to show some of the work done by them, as illustrated on page 40 in Figs. 10 and 11. Many railways have cranes installed every 200 miles of their track. Wreckage which would formerly have taken a day for removal is now cleared away in an hour or two. The largest engines can be lifted bodily and placed upon the track.

In lifting loads weighing 100 tons, added stability is given to the crane by a system of telescopic outriggers which are thrown out on the side of the car nearest the load and are usually blocked up to keep the car level. When the outriggers are not in use, they may be drawn back into the car so as not to interfere with traveling over the road. One of the limiting conditions in lifting heavy loads becomes evident when endeavouring to block up under the outriggers. It is often almost impossible to find ground work that will withstand the enormous pressure.

The workmanship in such large machines is necessarily of high quality, and most of the construction is in steel. All the gearing has teeth cut from solid blanks. The main machinery, together with the boiler, is contained within heavy frames mounted upon a cast-steel bedplate, thoroughly secured to the car body. In lifting, the strains are taken by a large center pin in the baseplate.

The locomotive crane is probably as compact a machine for its size and capacity as any structure coming within the category of cranes. In the case of large shipyard or wharf

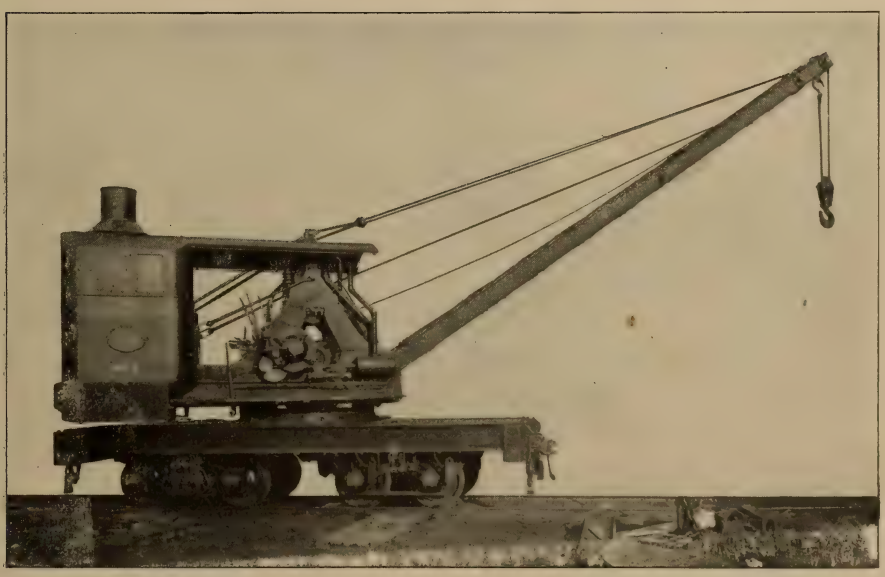


FIG. 12.—A 20-TON SELF-PROPELLING CRANE MOUNTED ON EIGHT WHEELS FOR RAPID TRANSIT

cranes, there is unlimited overhead space for the construction of high vertical struts to reduce strains, and the gauge of the track may be suited to the load. A locomotive crane, on the other hand, is limited in height and width, and is generally placed upon a standard or smaller gauge. This necessitates a careful arrangement of all parts to obtain the greatest stability with minimum weight.

In the placing of machinery three points are kept in view:—First, placing engine shaft, drums, and gears to keep the center of gravity as far back as possible from the center of the crane; second, to arrange them so that any part may be accessible for making repairs and convenient in assembling; third, to give the operator an unobstructed view from the operating platform. When the crane has been built as light as possible, with all parts heavy enough to withstand the stresses to be encountered, and the greatest stability has been obtained from the weight of these parts, counter balance is added in the form of scrap ballast. A sufficient amount to give a crane its rated capacity in foot-tons is generally placed in the car body of the crane.

Small cranes of from 5 to 15 tons are usually placed upon a structural steel or solid cast-iron car mounted on four wheels. For lighter cranes the solid cast-iron car is suitable, but a structural steel car is preferable for heavier ones, as it is not so rigid and adapts itself to uneven tracks and curves while sufficiently rigid to preserve joints and retain its shape.

Cranes of larger capacity than 15 to 20 tons should be placed on cars with more than four wheels, as otherwise no track system can be kept in shape owing to the great concentration of weight brought upon one wheel. The weight is spread upon four additional wheels by placing a bogie axle at each side of the drivers. The propelling mechanism is not altered by this arrangement.

Fig. 12 shows a crane of 20 tons capacity mounted upon an eight-wheel car, one end being supported on a standard truck and the propelling end being arranged in rigid pedestals. The axle is connected through spur and bevel gearing to the engines. One lever throws the propelling gears out of mesh for rapid transportation over the road.

In the up-to-date crane, chains on the hoists have been replaced by wire rope, which works smoother, with less noise and gives a neater appearance. A train of steel gearing has been substituted for the propelling chain, making a more satisfactory drive and one less liable to breakage.

The standard types of cranes made by different manufacturers have similar features and fulfill about the same specifications. A standard ten-ton crane will have a propelling speed of 4 to 5 miles per hour, a hoisting speed of 50 feet per minute with full load, and a slewing speed of 3 to 4 revolutions per minute. Variations are often made from these standard types to meet special conditions. Where the crane is used as a switch engine and great propelling power and high speed are required, it would be equipped with large-sized engines and boiler. In climbing heavy gradients, the same condition of boiler and engine would be kept, but a greater gear reduction made.

Jibs of locomotive cranes, to maintain the lightest weight possible, should be straight. Where a curved end is necessary a heavier section of structural material is used to maintain the same strength. When short jibs are used, a curved end is often necessary to give proper clearance under the jib.

Only a few of the well-developed uses of locomotive cranes have been here described. The number of industries in which they are being found of service is constantly increasing. When once in use they become indispensable.

DESIGNING MACHINERY TO FACILITATE REPAIRS

By Joseph Horner

DESIGNING machinery to facilitate repairs is not the same thing as designing machinery to facilitate erection or assembling. The two may often coincide, but the first requires to be considered independently of the second. It is comparatively easy to build up a machine, however complicated, from the bottom upwards; but it is a very different matter, and often a very difficult task, to take out something from a lower, or central part and replace it with a new piece. If draughtsmen could hear the strong remarks made by the fitters who have to do these jobs against time, they would give more careful consideration to making provision for repairs.

Some firms who build machinery that is subject to hard duty make a point of giving great attention to this matter. For which their customers are duly grateful at a time of breakdown, and come again to them with new orders. It is short-sighted policy to construct machines in such a way that purchasers must send to the manufacturers for skilled men, and incur vexatious and perhaps costly delays, whenever a worn or broken piece has to be replaced. Of course, if a structure as a whole goes to smash, that is a different matter; but we are considering here only the question of repairs, the necessity for which is inevitable sooner or later.

Thus, the guiding principle should be to so design a machine that any broken or worn-out parts may be removed and replaced with the detachment of as few other parts as possible. There are some portions of machinery that never wear or break, and there are others that are very susceptible to mishap, or to suffer from severe friction, jar, or other duty. These parts are, or should be, known, their liabilities foreseen, and the subject of how to get them out quickly, brought into the scheme of design. It is thus that a fitter would naturally look at the matter, just as the moulder considers the best way to mould and joint a pattern, or a smith how to produce a forging by drawing down, upsetting, or welding. It is just the point that the designer who is not in touch with the shops would never think of, yet its neglect has been the frequent cause of much unnecessary expense, both directly and by reason of the delay involved.

The parts of machines that generally are most liable to need repair are the bearings, shafts, gears, slides, and in some mechanisms, portions that are subject to much jar, as parts of stone breakers, ball mills, rock drills, stamps, conveyors, and elevators.

From the point of view of the present subject we may first consider machines as comprising essentially the main framings, and the smaller parts they carry. In ordinary service, short of severe accident, framings seldom fracture, or wear. Nine times out of ten it is the smaller parts that have to be replaced.

There are two principal methods to be considered in this design; one is the facilities for the removal of main parts, the other that for the removal of the small parts. Thus, you may wish to take away a cheek, or leave cheeks or framings intact, and remove small parts.

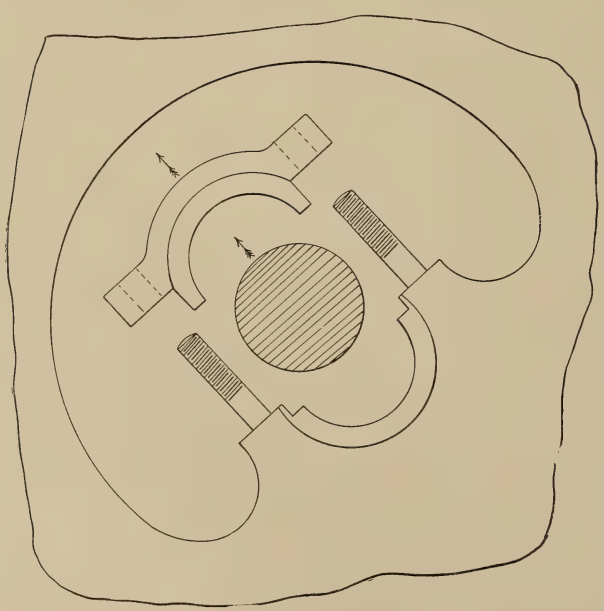
Cheeks are often made to be dismantled, but they can be so treated

only when in pieces. An entire framing cast in one piece, as, say, with cheeks and base together, affords no facilities for this. If framings are so made,—and there are economical manufacturing advantages in doing so,—then smaller parts must be taken out by endlong movements of the shafts, or by capped bearings, and these two methods open out a great many details for settlement. Similar problems arise when cheeks are bolted to bases, or connected by distance pieces, or stretchers, for there are objections to the dismantling that is involved in unfastening and removing a cheek, or cheeks, bodily, even though it be a practicable method.

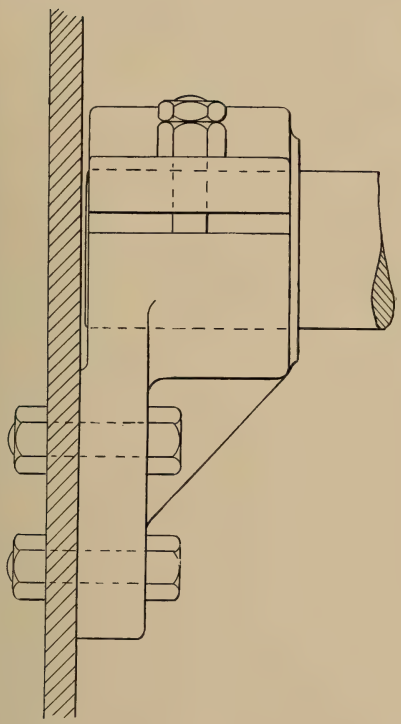
Considering, first, the removal of shafts by an endlong movement, this is made necessary in the absence of capped bearings, or as an alternative to the removal of an entire cheek. It is necessary if a shaft or its bearings become worn badly, or if gears, clutches, or other details carried on the shaft become fractured or much worn. Then the question is not merely that of the removal of the shaft, but of leaving the work it carries behind, the shaft being drawn through the bores, which may be rusted, or what is generally more troublesome, the disengagement of the keys. This would not matter so much if there were plenty of room in which to work, but often a shaft lies below, or behind others, or is partly obscured by brackets or other portions, and before it can be removed others have to be taken away also, doubling or trebling the work unnecessarily.

This is the evil which occurs more frequently than any other in complicated machinery,—the partial enclosure of vital portions,—and which may at any time involve several hours, or sometimes days of useless work and annoying delay. The more a machine is subject to rough and severe usage, and therefore liable to accident, the more carefully should such designs be avoided.

If it were not for the numerous fittings of wheels, levers, and clutches, with which shafts are generally equipped, there would be little objection to endlong withdrawal, provided, of course, that the shaft has no enlarged central portions. But the several fittings must be loosened by unkeying or otherwise, before the shaft can be drawn out, and this is where the work lies. It is a barbarous practice to drive a shaft through its surroundings, being risky and jarring to everything concerned; but it is often the only method available. In view of this, feather keys are preferable to gib head keys, because the former being fast to the shaft, can be driven through its bore better than a gib head key can be pried out, or



A CAPPED BEARING IN OPENING IN THE CENTRAL PORTION OF A FRAME



A CAPPED BEARING FITTED AGAINST INSIDE OF STEEL-PLATED FRAME SO THAT SHAFT CAN BE LIFTED OUT VERTICALLY

loosened with lever, or wedge, and hammer in the confined situation. When a wheel or pulley is located between other parts closely adjacent, the gib head key cannot be used, but the sunk feather only.

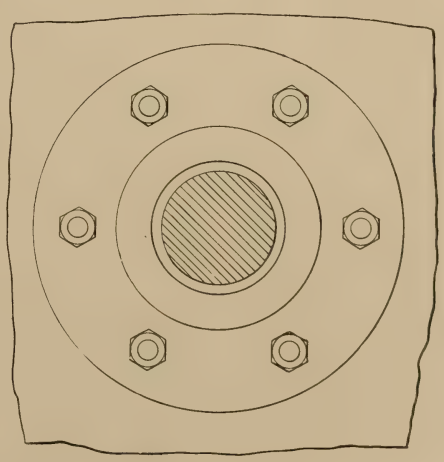
For these reasons it is poor practice to employ the dead-eye form of bearing in cases where shafts overlie one another, even though the first cost of construction is lessened by their use. Capped bearings alone are consistent with good design, because shafts with all their fittings can then be lifted out bodily, and each separate piece taken off conveniently at the vise by driving the piece off the shaft, instead of reversing the process. Often, too, the hydraulic wheel press can be used for such work.

Then the fitting of new parts is simply a reversal of the foregoing. They have to be fitted first in any case. Then if the shaft has to be put in endwise, the fittings must be put on with some difficulty in the act of pushing the shaft through, the trouble increasing with their weight, awkwardness of shape, and number. But if the shaft can be lifted out bodily, it can be put back similarly, with its parts all on, properly fitted.

Sometimes a difficulty arises, as when a shaft comes in the central portions of a mechanism, away from the edges of the cheeks or framings. The outlines of framings are largely modified to suit such cases, but when that cannot be done then an opening can be cast in the check and a capped bearing made, with room enough left above it for getting out the shaft, together with any pinions or other mountings of moderate diameter.

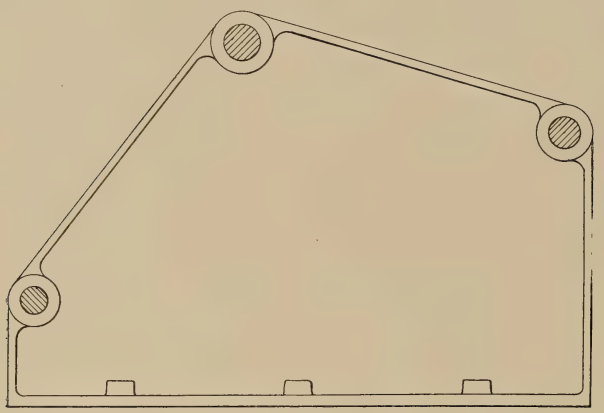
If steel-plate frames are employed, such bearings can be fitted internally as castings, much as they are fitted to the edges of plating, and then the shaft can be lifted out perpendicularly. When this is done, the shaft may be enlarged, if necessary, about the central portions, without causing trouble. Also, frequently, nothing except the broken or worn-out part need be removed if it happens to come outside others.

The methods of fitting bearings should be such as to facilitate re-

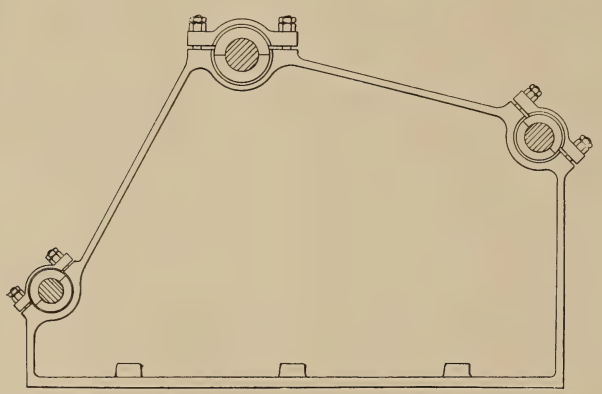


AN ORDINARY DEAD-EYE BEARING, BUSHED

pairs. The use of simple bushings is helpful when these and their shafts wear. In some cheap work, iron runs in iron, and there is no chance to refit, except by taking the job back to the machine shop, reboring, and then bushing. With brass bushings fitted, these can be removed,



A FRAME WITH SOLID EYE-BEARINGS. SHAFTS MUST BE REMOVED ENDWISE, OR THE FRAME UNFASTENED AND DRAWN OFF THE SHAFTS



A FRAME FITTED WITH CAPPED BEARINGS

leaving true concentric holes for the insertion of new bushings. A shaft reduced in the journals can then often be saved by inserting bushes of smaller bore. The same remark applies to brasses in divided bearings. Their seatings remain, and new brasses can be bored smaller to suit worn shafts.

Toothed gears are especially subject to fracture and wear. Portions of teeth may be broken off, and arms or bosses fracture, so that these parts are often the subject of special provisions. Generally it is a mistake to cast two or more gears together, because if one fractures, its fellow also is condemned. Gears are often cast in hard, durable material, as steel, phosphor bronze, or other alloy, or are made of rawhide when prolonged life and a minimum of repairs are desired. With a view to save time in repairs, gears are often cast in halves, and bolted on their shafts between other parts. This is absolutely necessary in some cranked shafts, and it would be desirable in many instances where it is not done.

The curb rings, or slewing rings, of cranes are too often cast in one piece, and that means that whenever teeth break or wear badly, and the duty imposed on them is very severe, all the superstructure must be lifted off, and the jib dismantled before a new ring can be put on. This trouble is saved in many cases by casting the ring in halves, and bolting, thus closing it laterally instead of lifting it vertically.

A similar case is that of belt-pulleys. Formerly these were invariably solid, except when it was absolutely necessary to divide them for insertion in place, as when end-long fitting was impracticable. Now for pears past the practice of dividing has been displacing the solid boss as a matter of convenience, so avoiding the driving fits which give such great trouble, besides involving

risks. This screw boss is another device which permits of using solid pulleys without having to resort to end-driving to get them on and off.

The foregoing are ordinary every-day illustrations applicable to all classes of work, but there is a large group of repairs which should be provided for both in the system of spare parts and the more elaborate system of interchangeable parts. The distribution is important, because spare parts may not be, and generally are not interchangeable in the strict modern meaning of the term. Spare parts generally require fitting, but this is reduced to a small amount, such as may be done by an attendant away from the shops. Parts that are interchangeable are ready to be put in place without any fitting whatever.

When a firm supplies spare parts, they must perforce make these a portion of a shop system; first, in the simplification of design, or in the reduction of fittings to the fewest possible consistent with efficiency; second, in taking means to prolong the natural life of each piece as long as possible by the selection of materials best adapted for prolonged duty; and third, in having a code by which any piece can be ordered and fitted without a drawing or any other aid.

With regard to the first, there are two counter tendencies. One is to lessen parts, the other to increase their number and compexity. Firms doing standard work generally try to cast or forge as much as possible in one piece. This lessens cost, but it makes repairs much more troublesome. If, for instance, a double cylinder is cast, with, say, steam chests, foot, and guides in one piece, a fracture or serious wear of any portion involves either a new casting or a new section made and fitted to the old portion. A new section is generally too expensive and so, if the mischief is serious, the entire casting and some of its fittings have to be thrown away. If the same engine were built up in separate sections, the failure of one section could be easily rectified. There are thus two sides to this question of casting as much as possible in one piece. It is good for construction, but not desirable for repairs.

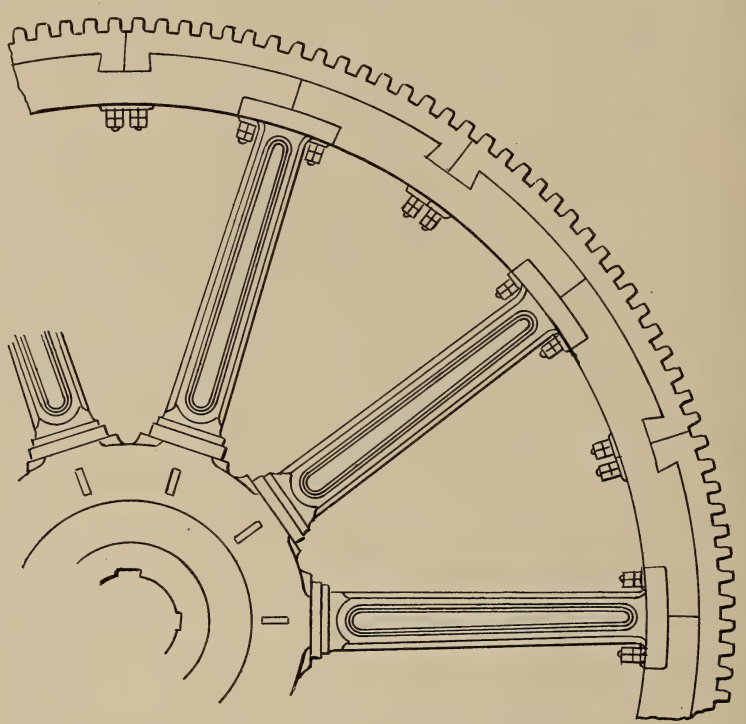
In many instances the system takes another aspect. Some parts wear so rapidly that they must be made detachable, to be fitted with no trouble whatever. Instances that readily occur are the grooved jaws of stone breakers, the head of battery stamps, the points of ploughshares, the bottom of mortar mills and grinding mills, and the plates of ball mills. In each of these cases the actual parts on which the work devolves are made separate from the rest, and are inserted without any fitting whatever, and stocks of these spare parts are generally kept ready for instant renewal.

The prolonging of the natural life of parts specially subject to accident or wear, is effected by special design, by selection of proper materials, or by both combined. Parts that are specially liable to break are thickened in the weak sections, or the general design is modified as experience dictates, or bearing areas are increased. In effecting such changes it is necessary to keep full records of all machines on which certain designs are used, in order not to send the wrong parts for replace orders in subsequent years. The materials selected may be specially tough to withstand stress and to endure frictional duty, as in chilling stamp heads, and in plates for various grinding mills. Included, also, is the selection of good bearing metals, the substitution of steel, bronze, or malleable iron for cast iron, etc.

The code by which new parts are supplied may be that of register letters and numbers, cast or stamped on every piece. An engine or machine is mapped out in the drawing, each piece is given a letter and number, and every similar piece on

all the orders made from that drawing has the same letter A, or B, etc., common to the entire engine or machine, with a number for the particular piece. Thus, if there were 150 pieces in the mechanism, there would be 150 numbers, and one letter, by which any piece could be ordered at any time.

The system of interchangeability is a substantial development of that now going on is as favourable to repairs as to first construction. It promises to do for channels, joists, tees, angles, and other sections,—for wire, tubes, and much besides, what standard screw threads have done for mechanisms. We can hardly realize the state of things that existed when there were no standard threads, but when different manufacturers had threads of their own. As dimensions



AN UNDESIRABLE METHOD OF FITTING TOOTHED SEGMENTS ON A FLY-WHEEL

of spare parts. It tends to the simplification of mechanism. It makes renewals easy of accomplishment. It is not suitably adapted for large pieces, but only for those of small and medium dimensions. Repairs in the form of patches, often done in large mechanisms, are seldom attempted in the smaller kind. It is cheaper to slip in a new piece, for repetitive work is as cheap as it is superlatively accurate.

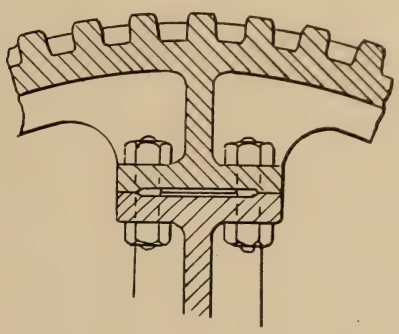
The standardization of materials and sections are lessened in number, repairs will be facilitated.

There are some features which might be considered minor elements in design, but their omission would give much trouble. Ordinary bolts are suitable for work when both head and nut can be grasped with spanners, but when built into a mechanism, it sometimes happens that the heads are not approachable. In such cases, bolts with square necks should be used, or bolts with a nib

under the head, just as is used in circular-headed pins that must not turn in their holes.

Very often valves and seatings cannot be got at after pump parts are finished. This should be foreseen, and holes left in front of such fittings through which to effect any necessary repairs. The holes should be closed with covers when not in use.

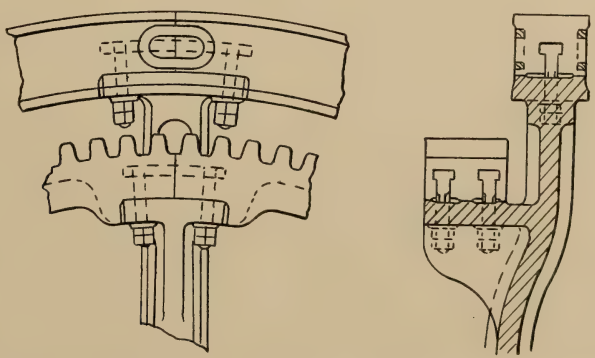
Often the provision for repairs takes the form of a permanent crane over a heavy mechanism, as travellers in power houses and over the cylinders of marine engines.



A CONVENIENT METHOD OF FITTING HEAVY TOOTHED LUGS TO ARMS

In the design of the spur rims of fly-wheels, in view of breakage and facility for repairs, two methods are in use. In one, the toothed segments are attached to the rim; in the other, to the arms. Some years ago Mr. Michael Longridge, the well-known chief engineer of the Engine & Boiler Insurance Company, of Manchester, pointed out that the first method courted disaster. "To place the spur rim, whose velocity should be low, on the outside of the fly-wheel whose velocity should be high, is contrary to common sense." Besides the question of relative speed, the attachment to arms is made with much greater facility than to the rim. In working, too, the stresses due to the transmission of 10,000 H. P. or more, are so severe that the segments grind and tend to slide on one another, with ultimate fracture.

The whole question of fitting large segments to fly-wheels is a difficult one, as is evidenced by the numerous different designs adopted. Large toothed rings are built in segments for convenience of casting, but the same plan is often adopted in rings so small that they might very well be cast in one, the object being, in case of fractured teeth, to replace the broken segment with more ease and at less cost than would attend the replacing of an entire ring. There is rather less reason for this now than in the old days, when segments were fitted with clipping strips to mill wheels and cranes; but the practice is still economical. When practicable, such segments should always be provided with a check to



THE BEST METHOD OF FITTING TOOTHED LUG SEGMENTS TO A FLY-WHEEL

make concentric joints with the parts to which they fit, so as to avoid trouble in centering.

It is poor practice to cast teeth directly on fly wheel rims, as is often done. The life of the wheel depends on the soundness of its teeth; if any of them break, the wheel must be thrown away, or new teeth dovetailed in. The latter method is practicable enough, but unless the teeth be fitted very carefully, they will not afford permanent security, and the heavy metal in the rim is liable to "draw" the teeth, which again tends to lead to fracture.

The same principle is adopted in related work, such as that of rings of teeth cast on flanged running wheels, where the whole job is at the mercy of the stresses and accidents to which the teeth are subjected. In good work they are cast separately and bolted together. Another example is that of brake rings cast on the toothed wheels of cranes,—a practice which is not to be commended in the large wheels at least. Sometime the teeth fracture before the brake ring is worn, or the ring may wear down thin before the teeth suffer; it is a kind of Siamese twin arrangement, —risky for both.

In steel-castings, another evil results from the casting of toothed wheel and brake ring together, shrinkage causing stresses on the arms which sometimes produce fracture and always result in inaccuracies, circularly. In good practice, therefore, the two are cast distinct and bolted together with a checked or registered joint; then the failure or wear of either involves the replacement of one only instead of both.

A good general rule is that the more inaccessible the parts of a mechanism are, the more care should be taken to avoid risk of breakdown. There are many such parts in the largest engines,—marine and land, —in the interior fittings of machine tools, and elsewhere, to which it is judicious to give an excess of strength for the reason mentioned

Another good rule is to give special attention to the strength of any mechanisms on which the continuance or serious interruption of important work depends, examples of which are the mill engines that drive an entire factory, the engines, propellers, and propeller shafts of a large steamship, the electric machinery driving cranes, lighting a city or charging steel furnaces and cupolas.

The greatest difficulty experienced in the use of blast furnace gas for gas blowing engines has been that due to the dust, and tarry matter, which interferes with the continuous working of the driving engines. A good illustration of this kind is to be noted in the design of the now well-known Nürnberg blast furnace gas engine. The purification of blast furnace and producer gas is often not perfect, and in order to prevent risk of damage to the valves and pistons by the scouring action of dust and other impurities, it is recommended that the valves and cylinders be examined monthly. The back and front cylinder covers are made movable to permit easy access to the valves and the pistons can be removed by disconnecting the connecting rod from the piston rod, taking out the latter with the front cover. The rods are disconnected at the center to liberate the back piston, the engines being tandem.

Duplication is the first aid to repairs. Even when duplication is not necessary, it may prove economical of time, because of the leisurely and thorough way in which repairs can be carried out. It is not necessary to wait for breakdowns to occur, for a duplicate set of machinery can be overhauled from time to time, and the sets used alternately.

Steam and water pipes are often very much in the way of the fitter who is doing repairs on engines, and joints must be broken and sections removed that interfere with the work. From this point of view,

facility of disconnection is a requisite. Flanged pipes and fittings are for this reason often preferable to screwed ones. Instantaneous grip coupling joints are useful in some cases.

The fitting of air-pump buckets to their rods is often faulty from the point of view of repairs. Mr. Longbridge has mentioned twelve instances of these, fastened against a cone or collar by nuts or collars on the under side. As these fastenings could not be examined without withdrawing the buckets, the result was that they were neglected until they got loose or broke, and the buckets dropped off the rods, and so were pounded to pieces. He suggested that the collar or nut should have been on the upper side. Thus the making of suitable provision for examination and repairs would prevent more extensive repairs, following accident.

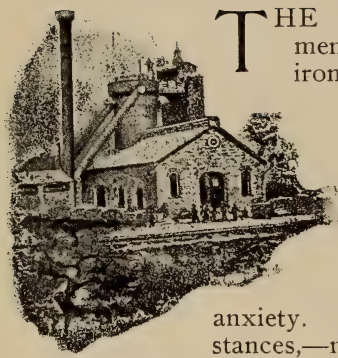
There is the well-known difference in outside and inside cylinder locomotives regarded from the point of view of repairs, and the same difference occurs in the engines of many steam cranes. It is more difficult to execute repairs to valve gears situated inside than out, not merely because of the awkwardness of getting at them in confined situations, but by reason of the parts which must be dismantled before they can be reached. In this, which is typical of much else, it is a good principle to place vital mechanisms in situations where they can readily be exposed for examination and repairs. When small gears and shafts are enclosed in machine tool framings, a door-way of sufficient area should be left for the purpose just mentioned.

A familiar illustration of design absolutely necesary for repairs is afforded by deep well work, in which "fishing" tools are employed for getting out broken drills, and worn and damaged valves, which must be replaced by new ones. These cannot be seen,—they can only be fished for, often hundreds of feet down.

GREAT BRITAIN'S IRON INDUSTRY

FROM A BRITISH POINT OF VIEW

By T. Good



THE future development of the British iron trades, upon which the commercial prosperity of the country so largely depends, is a subject not only of great interest, but of some anxiety. New circumstances,—new conditions of foreign competition, have arisen; where once there were customers there are now rivals. Great Britain must recognize that it has no longer an absolute monopoly in any branch of industry; that in some directions it has already lost the leading position; that in others it is being more or less rapidly overtaken; and it is a question whether the British are not labouring under some unfair conditions of fettered enterprise and restricted effort against which they cannot reasonably hope to struggle successfully in the future as competition becomes keener.

It is not the object of the writer to take any part in the fiscal controversy, nor to sound any note of pessimism; he holds that there is nothing in this growing competition to be afraid of, nothing to frighten either capital or labour, and that there is no need to adopt any ill-conceived measures or doubtful experiments in the interests, or alleged interests, of British industry, but he begs to urge the imperative need of cultivating a more ready adaptability to new ideas, new times, and new circumstances.

Great Britain's proud position in the world of trade and commerce was not attained without effort, nor will it be retained without exertion. The time is here when it cannot well afford to ignore a single commercial obstacle or industrial blight which it is possible to remove. Wherever there is room for improvement in method or policy, that improvement has got to be made without undue delay, or prosperity has got to suffer. And, with the possible exception of agriculture, in no direction is there greater need for improvement than in the foundations of the British iron industry.

Before offering any criticism of present methods, or making any effort to forecast the future, let us take a glance backward. Half a century ago Great Britain produced as much pig-iron as the rest of the world combined. In 1855 the output was 3,200,000 tons. From that time the actual, but not relative, output steadily increased until 1872, when it produced 6,741,929 tons, valued at over £18,500,000. Then the output declined steadily until the production for 1879 fell to 5,995,337 tons, valued at less than £15,000,000. Each of the next three years showed a slight increase,—the production of pig-iron in 1882 being 8,586,680 tons of a net value of £24,042,704. During the years 1883, 1884, 1885 and 1886 production and price fell, until the year 1886 showed but 7,009,754 tons worth £15,888,775.

By 1889 it had improved up to an output of 8,322,824 tons and a value of £20,390,918, while the following year for a smaller quantity, producers received over £24,000,000.

Then both quantity and value fell to 6,709,255 tons and £17,276,332 in 1892, and to £15,898,445 for an output of 6,976,990 tons in 1893, which was the year of the coal strike in the Midlands,—the strike having commenced on July 28 of that year. During 1894, 1895, 1896, 1897 and 1898 there was a steady improvement. In 1899 a record in quantity was established, and in 1900 a record in price, the figures being:—1899, £32,661,373 for 9,421,435 tons; 1900, £37,622,549 for 8,959,621 tons. Since then the output has slightly decreased and the value has considerably declined. In 1903 about 8,800,000 tons of approximately £22,000,000 value were produced, and in 1904 about 8,500,000 tons of about £21,000,000 value. Table I gives the British output of pig-iron in the five-year periods from 1854 to 1900, and separately for the last six years.

TABLE I.—PRODUCTION OF PIG IRON IN THE UNITED KINGDOM, INCLUDING THAT MADE FROM FOREIGN ORES—AVERAGES

Years	Quantities in Millions of Tons	Years	Quantities in Millions of Tons
1855-9	3.5	1895-9	8.7
1860-4	4.2	1899	9.4
1865-9	5.0	1900	8.9
1870-4	6.3	1901	7.9
1875-9	6.4	1902	8.6
1880-4	8.1	1903	8.8
1885-9	7.5	1904	8.5
1890-4	7.3		

As recently as 1874 Great Britain produced 47 per cent. of the world's iron; in 1890 it produced but 27 per cent., and last year not more than 17 per cent. As iron producers, the British held first place until 1895, when the United States got ahead of them; in 1903 they failed to retain even second position,—being beaten by Germany. While the world's demand for iron and iron goods has increased enormously, British production has remained practically stationary. Whether we go back ten years, or twenty years, or thirty years, we find that Great Britain's actual output of iron has not materially increased, while relatively to the world's demand for, and comparatively to its rivals' production of, iron it has lost ground to a very considerable extent.

While in iron production the British have been standing still, and, per head of population, losing some ground, other nations have been going ahead by leaps and bounds. During the last twenty years the French have increased their output by about 30 per cent.; the Belgians by 50 per cent.; the Germans by 300 per cent., and the Americans (U. S.) by about 400 per cent. Twenty-four years ago Great Britain produced 4½ cwts. of iron per head of population annually; to-day, when the world is using double, if not treble, the quantity of iron it did then, the British are only producing 4 cwts. per head. During this decline from 4½ to 4 cwts on per capitum basis, Germany has increased from 1 to 3⅓, and the United States from 1¼ to 5¼. This proves that the British are losing their grip on the world's iron market. This would not matter so much from a national standpoint but for the fact that in another great branch of manufacturing industry, viz., textiles—no progress relative to increase of population has been made in Great Britain during the last quarter of a century so far as the supplying of other markets is concerned, while in agriculture there is shocking and shameful lack of enterprise and progress.

And not only are the British being elbowed out of markets abroad in which there is an ever-growing demand for iron and iron goods, but they are being undersold in the home markets. During twenty-five years while British exports of iron and steel and manufactures thereof have increased by but a fraction per head of population, their imports of these things have increased by 300 per cent. Excluding iron-ore and scrap (raw material), the United Kingdom is now spending a round twenty-million pounds sterling per annum

TABLE II.—IMPORTS OF IRON AND STEEL AND MANUFACTURES THEREOF INTO THE UNITED KINGDOM

Description	Values in Millions of Pounds During Different Years 1880	1885	1890	1895	1900	1901	1902	1903	1904
Iron and steel of all kinds, except machinery and ships	2.2	3.7	3.4	4.4	7.7	7.5	7.9	8.6	8.2
Iron ore and scrap	2.7	1.9	3.5	2.9	5.6	5.6	5.0	4.8	4.5
Engines and machinery	...	...	...	...	3.6	3.9	4.7	4.4	4.3
Cutlery, hardware, implements, instruments, tools, etc., except musical instruments	...	...	...	...	2.0	4.3	4.4	4.2	3.7
Ships (new)	...	...	...	...	...	...	...	0.06	0.02
Motor cars and cycles	...	...	...	...	...	...	1.1	1.9	2.4
Cycles (not motors)	...	...	...	...	...	...	0.14	0.9	0.8
Telegraph cables, etc	...	...	...	...	...	...	...	0.05	0.05
*Totals (except iron o.e)	3.0	4.1	4.7	4.6	14.2	22.5	23.4	24.4	23.5

TABLE III.—EXPORTS OF IRON AND STEEL AND MANUFACTURES THEREOF FROM THE UNITED KINGDOM

Description	Values in Millions of Pounds During Different Years 1880	1885	1890	1895	1900	1901	1902	1903	1904
Iron and steel of all kinds, except ships and machinery	28.4	21.7	13.5	19.6	32.0	25.0	28.8	30.4	28.0
Iron ore and scrap	....	....	....	....	....	....	0.3	0.4	0.5
Engines and machinery	9.2	10.6	15.7	14.2	18.1	17.8	18.7	20.0	21.0
Ships (new)	....	....	....	....	8.5	9.1	5.8	4.2	4.4
Cutlery, hardware, implements, instruments, tools, etc.	4.5	4.0	4.4	3.3	4.0	4.1	4.3	4.6	4.8
Motor cars and cycles	....	....	....	....	....	....	0.17	0.34	0.67
Cycles (not motors)	....	....	....	....	....	....	0.7	0.8	0.7
Telegraph cables, etc	....	....	....	....	....	....	2.8	1.8	0.8
*Totals	42.1	38.30	47.5	50.0	64.0	59.0	63.7	64.3	62.8

Ships not included until 1900.

* Including articles not enumerated here.

in foreign iron and iron goods, and this while one-third of their blast furnaces stand idle.

That America has some natural resources superior to Great Britain will be readily admitted, although these are considerably exaggerated from time to time. But the disadvantages under which the British labour as compared with their American rivals are much more artificial than natural, while in contrast to Germany's progress, natural advantages cannot be urged in explanation. The indisputable fact is that the great progress in the production and manufacture of iron is primarily due, alike in Europe and America, to low mining royalties, low transit rates, and a ready adaptability to new inventions and ideas compared with the conditions prevailing in Great Britain.

The problem of trade is the problem of cheap and rapid production and transit, and whatever position Great Britain has attained in the past when, in an industrial sense, other nations were slumbering, it cannot reasonably expect to retain its supremacy in the face of keen competition if it continues to tolerate the present excessive rents, royalties, and transport charges, and to pursue generally a too conservative policy in industrial and commercial affairs.

The British stick too tenaciously to antiquated appliances and ancient ideas. Take, for instance, blast-furnace practice. The output per furnace in Germany is fully one-third more, on the average, than in the United Kingdom. With fully 50 more furnaces in blast last year than had Germany, the British production of iron was nearly 2,000,000 tons below that of their rivals, while in America, in 1903, 250 furnaces produced over 18,000,000 tons of pig-iron as against 350 in Great Britain giving an output of less than 9,000,000 tons.

The United States, having adjusted their recent financial disturbances, are now producing pig-iron at the rate of 22,000,000 tons a year, and there is evidence to support the belief that American exports of iron and iron goods will shortly assume proportions distinctly detrimental to the British. A good number of American furnaces, with their modern equipments, produce from 400 to 500

tons of pig-iron daily, and an output of 800 tons per day has been attained by special effort in at least one case. An output of 300 tons per day is quite exceptional in Great Britain.

The high-capacity furnaces of America, with their pig-iron casting machines whereby the work on the old-fashioned sand-bed is avoided, to mention but one point, have materially aided the American industry. Then again, the cost of labour both in the mining and manufacture of minerals is less in America than in Great Britain. Electric coal-cutting machinery, and other mechanical appliances in the mines, at the coke ovens and smelting furnaces, are much more extensively used than in the United Kingdom. The utility of these appliances is at once apparent when we note that against the British output of 275 tons of coal per year per man employed in and about the mines, the output in America is 526 tons. There are over 7000 coal-cutting machines at work in the United States, and they have reduced cost by from 15 to 30 cents per ton.

However, the British manufacturer has quite a plethora of candid critics continually tendering advice gratis, and advice at so much per column, and while, as a practical man, the writer of this article is well acquainted with the manifold shortcomings of the average British manufacturer and workman, he contends that there is another audience—the landlords—to which the critics of British industrialism should address some of their strongest remonstrances.

A great deal has been heard within recent years of land bills and fair rents courts for Ireland; it is time a move in this direction was made on behalf of the industries of Great Britain. It is an indisputable fact, blink it as we may, that the unfettered and unique land monopoly of the United Kingdom constitutes the heaviest burden now suffered by British industry and is the cardinal point in the problem of foreign competition. Hitherto, the British have prospered in spite of the land laws simply because they had no formidable competitors in manufactures, but now that other nations are developing their mineral resources, manufacturing for themselves and for export, copying the best British methods but discarding the worst ones, assisted by enlightened land laws and transit facilities, the time is at hand when the British must set about in earnest to mitigate the evils of rents, royalties, and railway rates excessively burdensome compared with those enjoyed elsewhere.

Cheap transport charges and low rents and royalties have been the primary factors in the rapid industrial development of Germany and America, and the British cannot reasonably hope to hold their own against these rivals unless they very materially reduce their cost of carriage and their mining royalties. Some ten years ago the Iron Trades Delegation to the Continent, upon their return, gave it as their opinion that if British ironmasters enjoyed the same mining royalties and railway rates as those of their rivals, foreign competition in neutral markets could be defied. And there was, and is, ample evidence to justify such a contention.

From a geographical standpoint the transit facilities of Great Britain should be superior to, and their cost cheaper than, those of their rivals. But as a matter of fact—thanks to a monopoly that has charged the railways such scandalous prices for land that they are saddled with capital charges twice and thrice as heavy per mile as those of other countries—the British railway rates are notoriously oppressive compared with those prevailing elsewhere, while the canal system is so antiquated and inefficient as to constitute a positive disgrace to an industrial community.

What has been done in the matter of throwing heavy capital charges upon the railways cannot very well be undone, but by insisting upon

having land at reasonable prices for the further extension of railways, by more intelligent co-operation among traders and between traders and railway companies, and by a much-needed development of the waterways, the cost of carriage could be materially reduced and the trade of the country materially increased. As it is, the railway rates for iron goods from works to port, distance for distance, are on the average 115 per cent. higher than those of Germany, 120 per cent. higher than those of France, and 300 per cent. higher than those of Belgium and America, while cases could be quoted where on the railways of America and on the splendid canals of Germany the cost of carriage for iron ore and other minerals is but one-sixth of the cost in the United Kingdom.

Another grievance which calls imperatively for redress if Great Britain is to remain a great iron manufacturing nation is in the matter of mining rents and royalties,—another phase of the land monopoly. In the various charges termed fixed rents, dead rents, lease-fees, wayleaves, waterleaves, airleaves and royalty per ton of minerals raised, there is a list of extravagant, exorbitant, and extraordinary tariffs levied unjustly upon British industry. These royalties,—to group the various charges under one heading, for they are all royalties upon, and add to the cost of, mining—average not less than 1 shilling per ton of coal.

This tax upon the production of coal, which is in turn a tax upon the general industry of the country, and especially upon the iron and steel trades in which so many tons of coal are used in the manufacture of a single ton of finished goods, is a much more serious matter than is generally recognized. On the most moderate computation it is possible to make, the average royalty on a ton of British pig-iron from ironstone, limestone and coal, is not less than 6 shillings. And this pig-iron with its tax is but raw material for the manufacturers, further quantities of coal having to be used in working it up. These mining royalties are fair examples of how public well-being is sacrificed to private privilege in Great Britain.

In Germany, mining royalties are fixed by the State at 2 per cent. on the profits of the undertakings, and no prejudice of the landowner is permitted to prohibit the working of minerals; in Belgium, at 2½ per cent. on profits; in France, all coal and ironstone being the property of the State, at 5 per cent. on profits, while rents are merely nominal, being about ½d. per acre, as against British rents of from £2 to £5 per acre on top of the lease-fees which are often excessive and sometimes prohibitive. In Spain, also, mining rights are leased on nominal terms, and in the United States royalties are practically unknown. While in Great Britain mining royalties are a burdensome tax on production, in the case of their Continental rivals they are only a moderate charge on profits, and herein lies a solid grievance.

Now suppose the British make a profit of 2 shillings per ton in mining operations, or what will serve the purpose of illustration better, suppose no profit whatever is made, the royalty charges will in any case reach about 1 shilling per ton. But if the Germans make 2 shillings profit their royalty will be one halfpenny; if they make 1 shilling profit they will pay but one farthing; while if they make no profit they pay no royalty. But in the former case, whether profits are made or not, whether the British can or cannot hold their own in the matter of price with competitors, the landlords' charges have to be met, or operations must cease.

The whole system of granting mining leases in Great Britain is fundamentally wrong, and is utterly opposed to industrial welfare. A lease is conceded for a term of years upon conditions mutually agreed to by tenant and owner, but when the lease

expires and the tenant company—their plant in full working order and their business established—desire a renewal, it can be obtained only on the landlord's terms, and if trade happens to be good at the time these terms are liable to be based on "boom" figures. Then, in the course of a few years, if trade slackens and prices fall and the landlord is not of a generous disposition, the inevitable collapse comes,—investors are ruined, workmen are turned adrift, and the plant becomes the property of the landlord.

This is no uncommon case. Quite recently the writer saw a mine idle, the machinery in a state of decay, and the cottages deserted simply through excessive royalties which could not be paid during a period of temporary depression. And this mine is situated where all the natural conditions are favourable to the industry; but, as often happens, one man is permitted to set the laws of nature and the needs of the community at defiance.

To further illustrate how these mining royalties handicap British industry it may be mentioned that some iron manufacturers pay more in the shape of royalties than in wages, and that the royalty charges on the bunker coal of a steamship amounts to more than the crew's wages. The writer knows of one case—a coal mine in Scotland—where the landlord's toll amounts to 3s. 6d. per ton of coal raised. He knows of another mine in Yorkshire paying no less than £40,000 a year in royalties on the output of two shafts. He could quote the case of a firm paying over £11,000 a year in royalties, but whose shareholders for nine consecutive years were without a dividend; another firm paying as much as £100,000 a year in royalties but nothing in profits for several years; and yet another—this time a typical, not an exceptional, case at all—paying £80,000 yearly in royalties, whereas a firm on the Continent with a similar output and making a similar profit would not pay so much as £3000 a year in royalties.

In reference to railway rates and mining royalties taken together, the writer will quote the case of a Yorkshire firm in competition with a Belgian firm for an order from the London County Council for rails. This firm uses Lincolnshire or Northamptonshire ironstone upon which royalties amount to more than a shilling per ton, but to avoid exaggeration we will put it at 1 shilling. It takes 4 tons of this ironstone to make 1 ton of rails. This makes, in ironstone alone, 4 shillings per ton of rails in royalty.

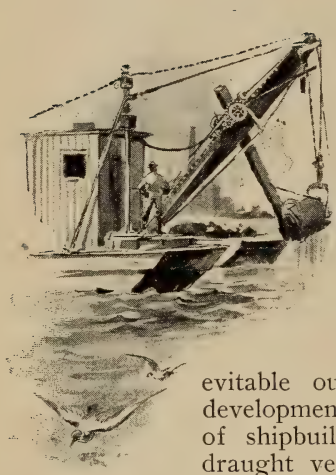
In the manufacture of this ton of rails there are used 3½ tons of coal. Taking the royalty upon coal to be only 6d. per ton, to again avoid exaggeration, and reckoning the royalty upon limestone to be only 3d., we have here, on coal, ironstone, and limestone, royalties amounting to 6 shillings per ton of rails as against the total royalty charges in Belgium of not more than 1s. 2d. To take a ton of these rails from Leeds to London costs 11s. 10d. Total royalty and railway rate, 17s. 10d. The Belgian firm can deliver their rails in London for 5s. per ton-carriage. This leaves a balance in favour of the Belgian firm of 11s. 8d. per ton in cost of carriage and mining royalties.

While other nations are going ahead by leaps and bounds in iron manufacture Great Britain is standing still,—fettered by a load of rents and royalties such as is not tolerated in any other country. Surely then it is high time to draw attention in unmistakably plain language to this aspect of the problem of foreign competition,—to this antiquated land monopoly which is slowly, but none the less surely, undermining the very foundations of the British iron industry.

DREDGING AND DREDGING APPLIANCES

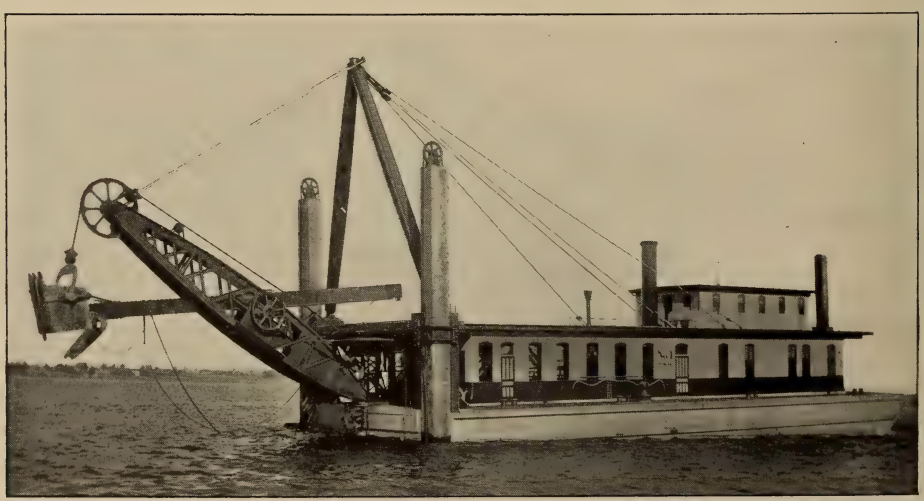
PART I.—DIPPER AND LADDER DREDGES

By Brysson Cunningham

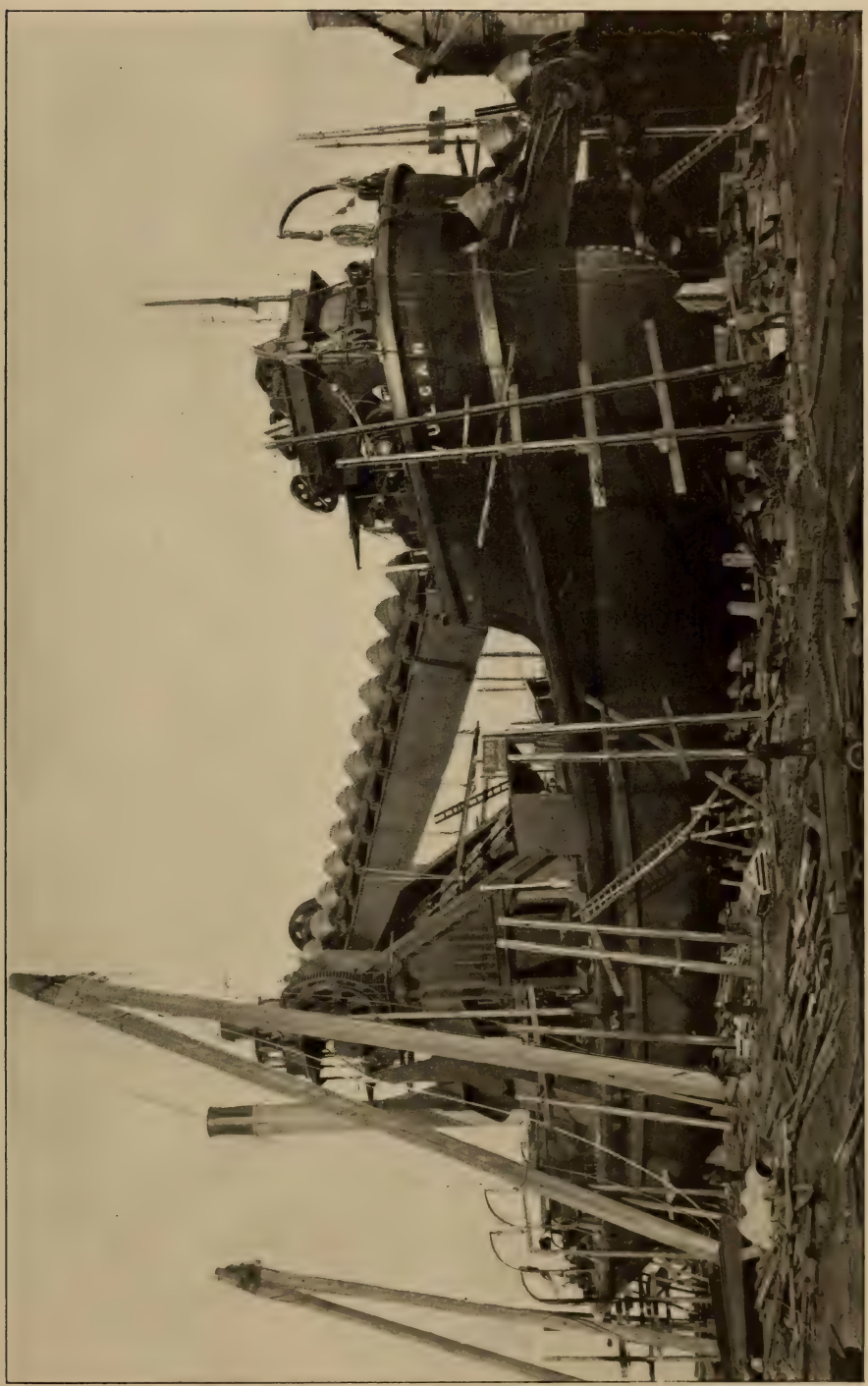


DREDGING is one of the most characteristic operations of modern maritime engineering enterprise. Nor is this a matter for surprise, seeing that it is a perfectly logical sequel to, nay more, the inevitable outcome of, recent developments in the science of shipbuilding. The light-draught vessels of our forefathers, capable of skimming over shallows which would strike dismay into the heart of a present-day mariner, have given place to huge hulls, immersed to double and treble the depth of their predecessors, and like icebergs, carrying their ponderous freight manly below the water line.

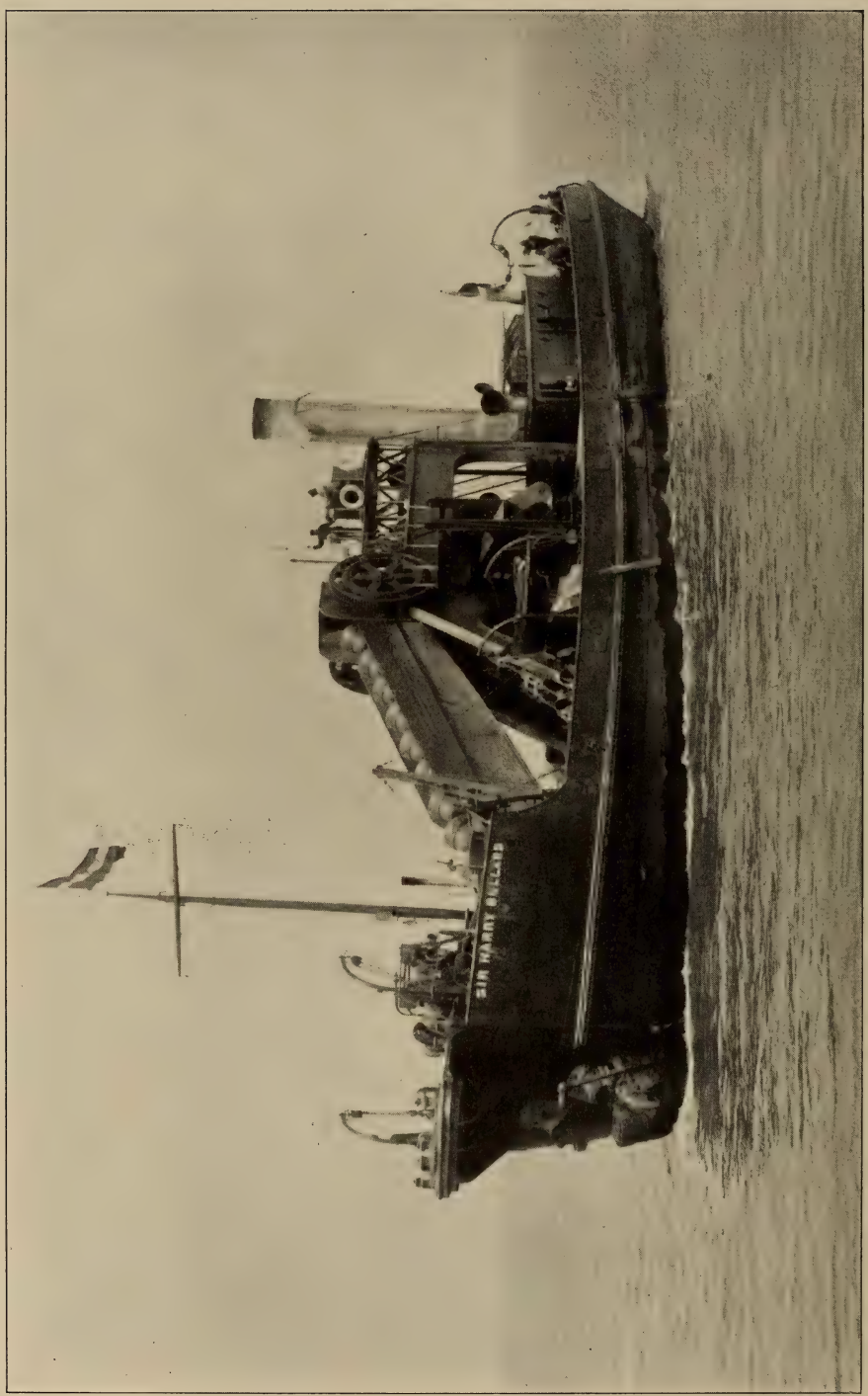
So recently as 1860, the deepest vessel in the Atlantic service did not exceed 24 feet, while in the P. & O. service the maximum was 20 feet, and in the Cape service only 14 feet. The most modern vessels have load-line draughts considerably in excess of 30 feet, and in the case of such mammoths as the "Celtic," the "Cedric" and the "Baltic," the full depth of draught attains to no less than 37 feet. The obvious corollary of these facts is that the entrance channels of ports, which served all useful purposes under less exacting conditions, are ceasing to be effective, and have to undergo a process of artificial deepening in order to adapt them to modern requirements. Nearly every port has, at least, one dredger at



A DIPPER DREDGE BUILT BY THE BUCYRUS COMPANY, SOUTH MILWAUKEE, WISCONSIN, U. S. A.



TWIN SCREW BUCKET DREDGER BUILT BY MESSRS. FERGUSON BROTHERS, OF PORT GLASGOW, SCOTLAND, FOR THE MERSEY DOCK AND HARBOUR BOARD. CAPABLE OF DREDGING 1000 TONS OF CLAY PER HOUR FROM A DEPTH OF 50 FEET



TWIN-SCREW BUCKET HOPPER BREDGER "SIR HARRY BULLARD," BUILT BY MESSRS. FERGUSON BROTHERS, PORT GLASGOW, FOR THE GREAT YARMOUTH PORT AND HAVEN COMMISSIONERS. CAPABLE OF DREDGING 500 TONS OF CLAY PER HOUR FROM A DEPTH OF 45 FEET HOPPER CAPACITY 400 TONS. SPEED 8 KNOTS

work, more or less continuously upon the maintenance and improvement of its approaches, and most ports of importance possess a fleet of such vessels in order to cope with developments, which are as rapid as they are revolutionary.

The expansion of oversea trade calls continually and insistently for increased accommodation, and the results achieved under this pressure, though invisible to the eye, are striking enough. Liverpool has deepened her bar channel by 16 feet within the last fifteen years, Antwerp has removed from the bed of the Scheldt extensive shoals, which limited her accessibility and hampered her trade, while New York hopes in a few years' time to acquire a navigable entrance affording a minimum draught of 40 feet. Ten powerful dredgers are continuously at work on the Mississippi, half a dozen on the St. Lawrence and twice as many on the Maas. The Seine, the Volga, the Danube, the Garoune, the Clyde, the Tyne, the Tees and a score of other rivers are the loci of extensive dredging operations. Dredgers are to be found at work at places so widely apart as Natal and Nicaragua, Adelaide and Libau, Shanghai and Copenhagen, Yokohama and Cronstadt,—in fact, wherever there is maritime trade and enterprise, and instances may be cited indefinitely.

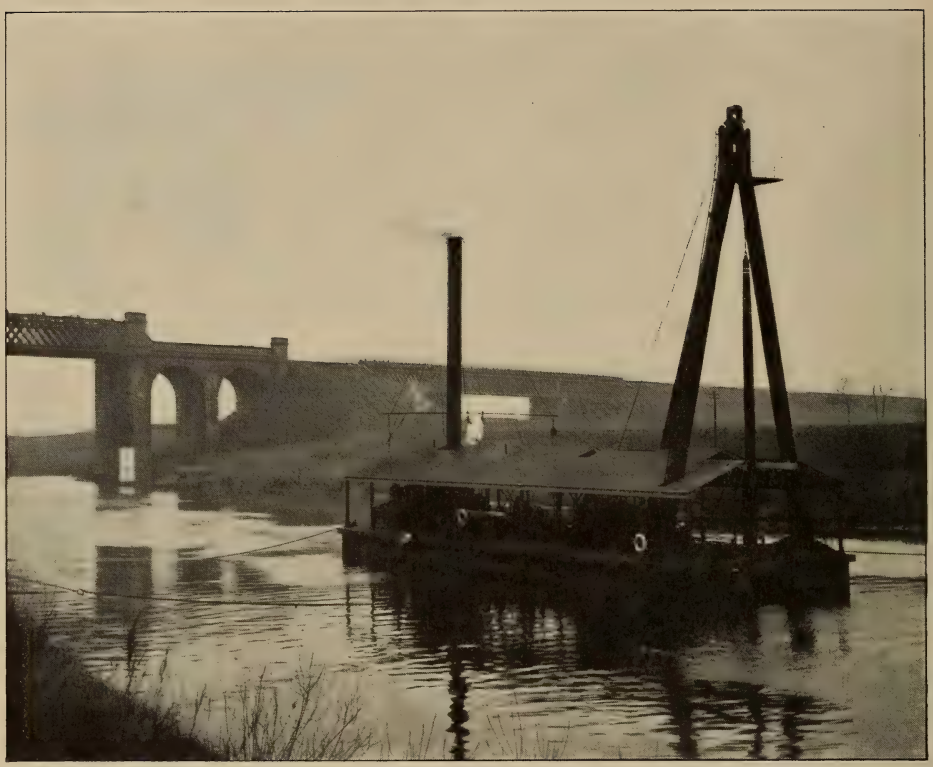
At first, dredging was carried on by small and almost insignificant agencies, but the scope of present-day operations has become so vast and extensive as to necessitate the employment of extremely powerful plant and appliances. Such primitive expedients as "the bag and spoon," the "aquamotrice" and the "rake" have given way to large and imposing vessels, self-propelled, navigable and specially equipped with machinery for dealing with unlimited quantities of material at rates of something like from one to four thousand tons per hour. Undertakings of enormous magnitude demand implements on a correspondingly gigantic scale.

The conditions of dredging work are most varied and exacting. Almost any combination of circumstances within the range of engineering experience may be looked for, and the obstacles encountered are often of the most formidable nature. The material removed ranges from soft, impalpable mud to hard rock, from loose sand to stick clay. Uniformity in any locality is the exception rather than the rule, and in the midst of friable strata, huge adamantine boulders suddenly obtrude an undesirable presence. An insidious deposition of silt, the shifting of a sandbank, the slipping of channel sides undo the work of months. Vicissitudes of climate, weather, tide, current and wind, have to be reckoned with, and, in addition, operations have to be conducted in such a way as to cause the least possible impediment or disturbance to the existing conditions of navigation.

All these matters occasion stoppage and delays, delays as frequent and considerable as they are vexatious and expensive. For instance, take the following statement (extracted from the report of the Chief of Engineers) of the working of the United States dredger "Gedney" at the entrance to New York Harbour during the twelve months ending June 30, 1904:—

	Days
Actual working time, parts of 112 days equivalent to	92¼
Work prevented by weather (fog, storm, etc.)	29¾
Occupied in general repairs during winter	154
Occupied in minor repairs	21
Lost from other causes	10
Sundays and holidays	59
	366

Thus, the net useful time was only 25 per cent. of the whole. Under very favourable circumstances it would not be safe to reckon upon more than 200 working days in the year. It is noteworthy, too, how large a proportion of the total time is occupied in repairs. Breakdowns are a common occurrence in dredging experience, and the expense arising from this cause is no inconsiderable item. The cost of repairs is



OBNITZ ROCK-CUTTING MACHINE AT WORK ON THE MANCHESTER SHIP CANAL. MADE BY MESSRS. LOBNITZ & CO., LTD., RENFREW, SCOTLAND

frequently from 40 to 50 per cent. of the sum allotted to working expenses, and it has on occasion equalled and exceeded the amount of all other charges.

It is little to be wondered at then that, in many cases, dredging operations prove hazardous, tedious and costly, that they call for the exercise of much patience and unfailing determination, and that sometimes the results seem scarcely commensurate with the trouble taken to obtain them. Channels, however, can be kept open only by constant attention, and where the very existence of a port is at stake, no expenditure hardly can be deemed too great, nor any efforts too persistent to avoid the commercial extinction which ensues when the means of accessibility are allowed to fall behind current demands and so into desuetude.

As varied as the operations are the types of dredgers themselves; naturally they bear a characteristic relationship to the particular class of work for which they are designed. Thus for rock, a type of dredgers is required which is altogether different from that used for sand. Dredgers, in fact, are built on two very diverse principles, which may serve as a basis for classification. Thus we have:

(*a*) Digging dredgers, in which the action is that of incision and raising by means of buckets, and

(*b*) Suction dredgers, in which the action is that of erosion and suction through pipes.

Of these two classes, the first admits of equally distinctive subdivision into (1) the ladder dredger, with a continuous band of buckets; (2) the dipper, or single bucket, worked at the extremity of a long lever, and

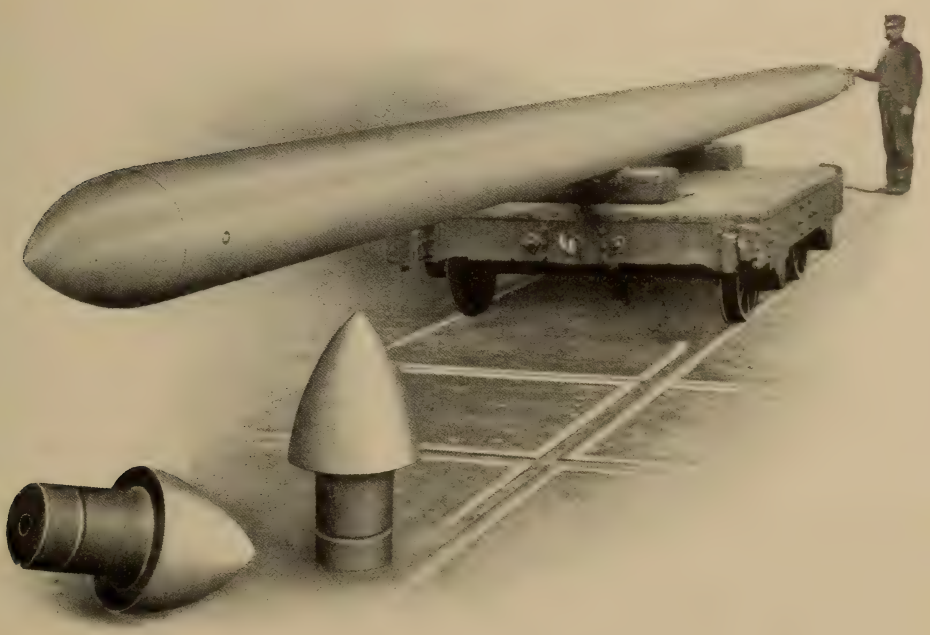
(3) the grab, or drop bucket suspended at the end of a chain.

Digging dredgers, as a class, have the advantage of greater power, but their efficiency is restricted by considerations of draught and weather. The suction dredger is more adaptable to these conditions, but it is much less effective for, if not altogether incapable of, dealing with hard material.

Of digging dredgers, the ladder dredger stands foremost in importance. The bucket ladder is, on the whole, the most satisfactory realization of an appliance for dealing with all sorts and conditions of material in an economical, efficient and expephery of a semi-ellipse and its major axis, about two pivots or tumblers set at different levels. The buckets excavate material at the lower tumbler and discharge it into a shoot while passing over the upper tumbler. The frame containing the tumblers constitutes the "ladder."

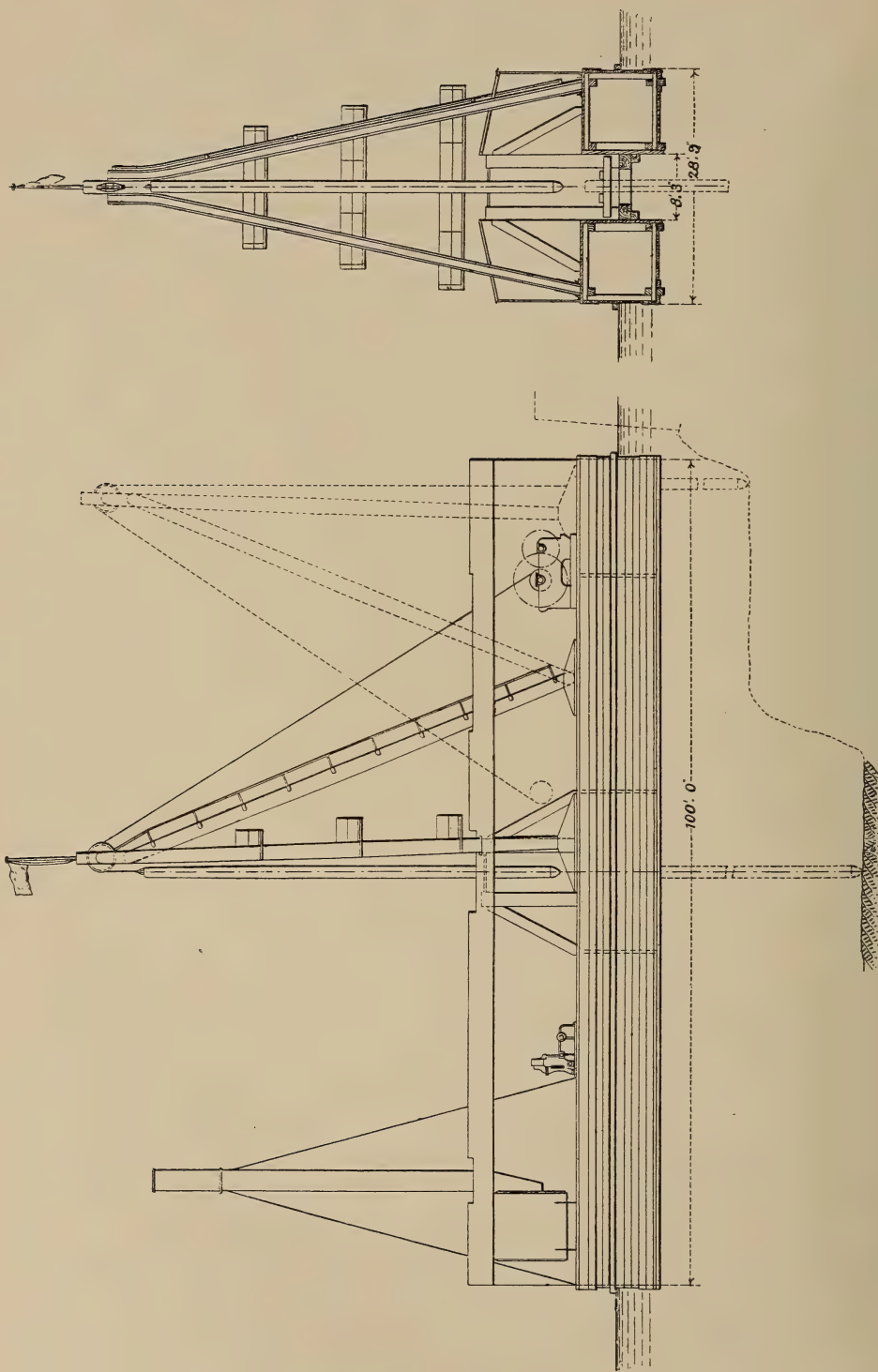
Dredgers of the ladder type have either one or two ladders. In single-ladder dredgers, the ladder coincides with the longitudinal axis of the vessel. In other cases the ladders are set at each side.

A single-ladder dredger of the same capacity as a double-ladder dredger has the advantage of fewer moving parts, and consequently of less work-

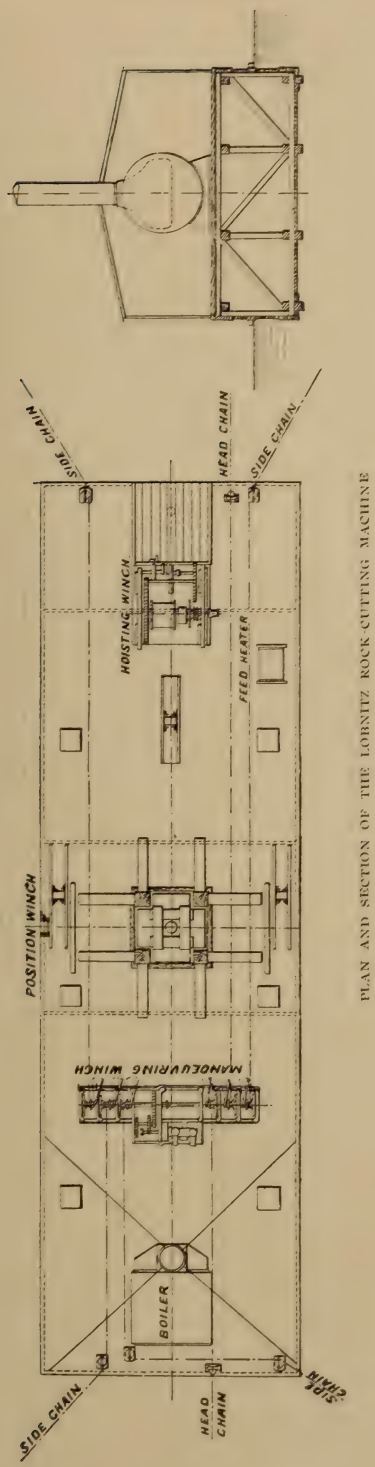


ONE OF THE LOBNITZ ROCK CUTTERS, SHOWING THE RENEWABLE HARDENED POINTS

ditious manner. There are other types more suitable for special kinds of work, but as an all-around machine the ladder dredger stands unrivalled. The principle on which it is constructed is that of an endless chain connecting a series of buckets which traverse in succession on an inclined path, approximately the periing friction. The central position of the ladder admits, moreover, of a more convenient outline for the vessel, from the point of view of propulsion and affords greater steadiness in a seaway. The broad beam of double-ladder dredgers renders it difficult for them to pass through narrow locks, though the difficulty has been



ELEVATION AND SECTION OF THE LOBNITZ ROCK-CUTTING MACHINE



PLAN AND SECTION OF THE LOBNITZ ROCK-CUTTING MACHINE

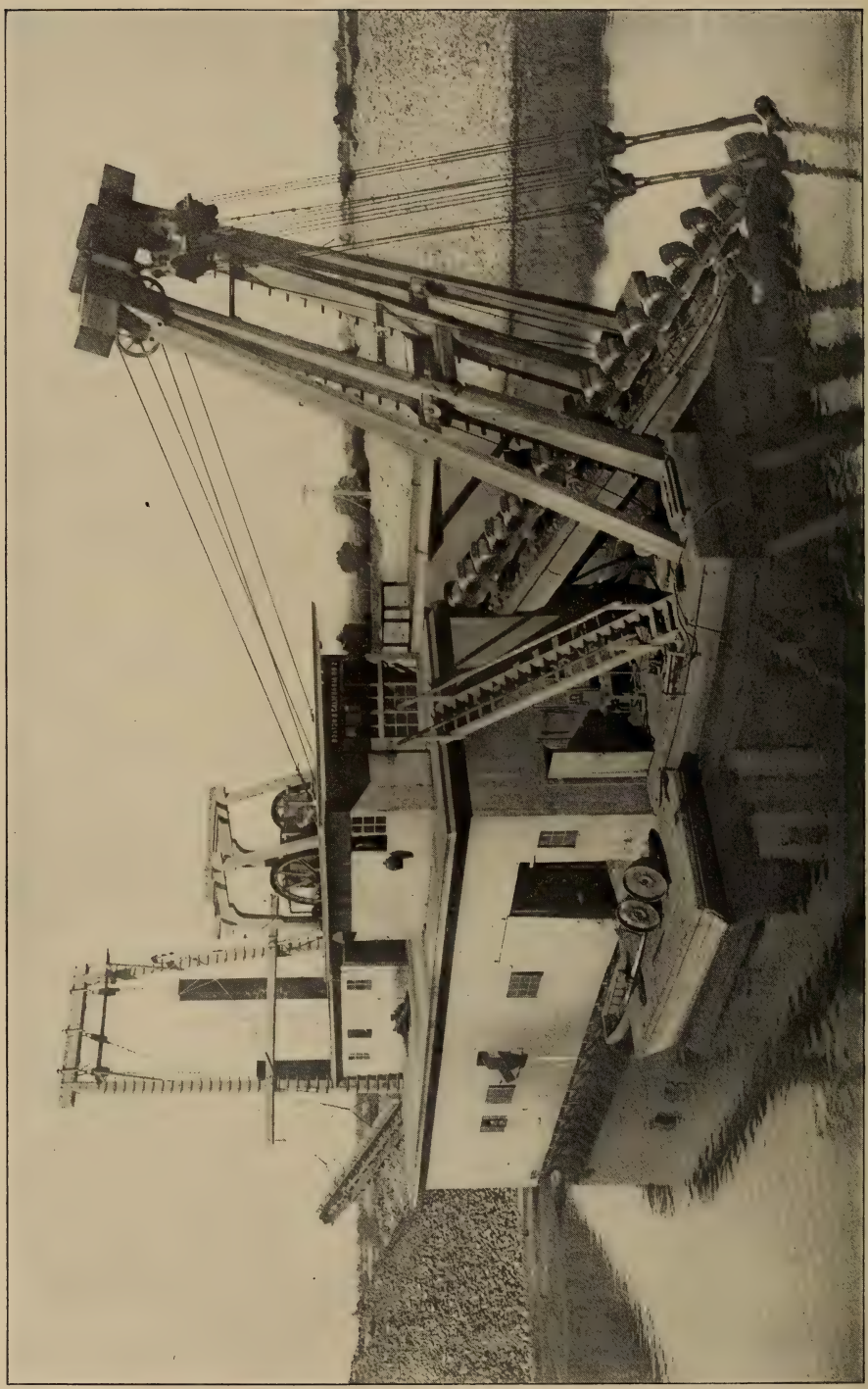
overcome, in one case at least, by constructing the dredger in detachable halves.

On the other hand, a side-ladder dredger can work in greater proximity to the face of a quay wall than is possible in the case of a central ladder. But under these circumstances the discharge of dredged materials has to take place across the whole width of the vessel (unless it be a hopper dredger, which is unlikely, owing to its unsuitability for navigation) and the lifts of the buckets must either be unnecessarily high or the cross shoot will be so flat as to be ineffective and will have to be flushed by an auxiliary pump.

A central-ladder dredger can discharge indifferently to either side, but *per contra* if any mishap occurs to a link or bucket, the whole dredger is put out of action, whereas in a double-ladder dredger, one ladder may be quite disabled without interfering with the work of the other. On the whole, the balance of evidence favours the single type for general use. Most modern dredgers are equipped with central ladders.

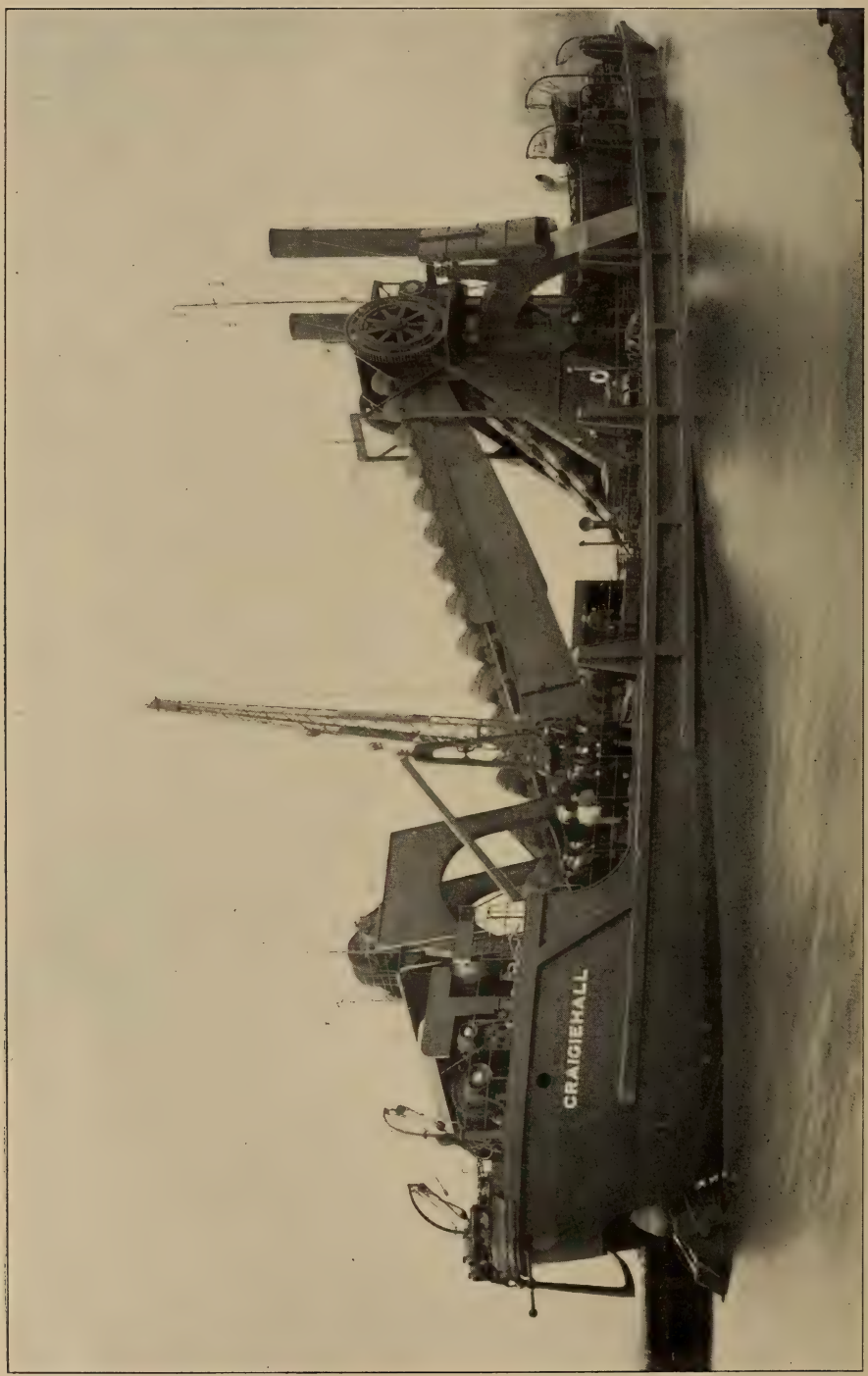
The bucket dredger is eminently suited for steady continuous work in hard material. It removes clay and marl with facility and is the only form of dredger which will excavate rock. Even if the clay be studded with boulders, the buckets are capable of lifting them to within the range of a deck crane. The buckets of a first-class dredger will readily lift stones weighing from 30 cwts. to 2 tons. A dredger at Bristol on one occasion raised a boulder weighing $2\frac{1}{2}$ tons without the slightest damage to the bucket. For dealing with firm rock the buckets are fitted with teeth along the cutting edge, or they are set alternately with spikes. In harder rock it may be necessary to do some preliminary blasting, or the material may be disintegrated by a rock cutter of the kind made by Messrs. Lobnitz & Co., Ltd., Renfrew, Scotland.

The Lobnitz device consists of a heavy chisel of steel weighing from



A LADDER DREDGE BUILT BY THE BUCYRUS COMPANY, SOUTH MILWAUKEE, WISCONSIN, U. S. A

BUCKET HOPPER DREDGER "TEREDO," BUILT FOR THE NATAL GOVERNMENT BY MESSRS. WM. SIMONS & CO., LTD., RENFREW, NEAR GLASGOW, SCOTLAND.
HOPPER CAPACITY 800 TONS. CAPABLE OF DREDGING 1080 TONS PER HOUR AT A DEPTH OF 40 FEET



TWIN-SCREW BARGE LOADING DREDGER "CRAIGIEHALL," BUILT FOR THE CLYDE NAVIGATION TRUSTEES BY MESSRS. WM. SIMONS & CO., LTD.

10 to 15 tons. The chisel is fitted with a hard cutting point and on being allowed to fall by its own weight from a suitable height say from 6 to 10 feet, on to the cleaned surface of the rock, the latter is splintered and pulverized to a condition compatible with removal by dredging.

Even the hardest rock is amenable to this treatment, being fractured like brittle glass. The cutter is capable of dealing with layers 3 feet in thickness at a time, and the blows are repeated until the required depth is obtained. The apparatus is mounted on a couple of barges connected by girders of wood or steel. The use of explosives tends to the production of unequally sized fragments, some of which are bulky and difficult to remove. By the rock-cutting apparatus the material is reduced uniformly to the size of ordinary ballast. Several of the Lobnitz appliances were used in the construction of the Suez Canal.

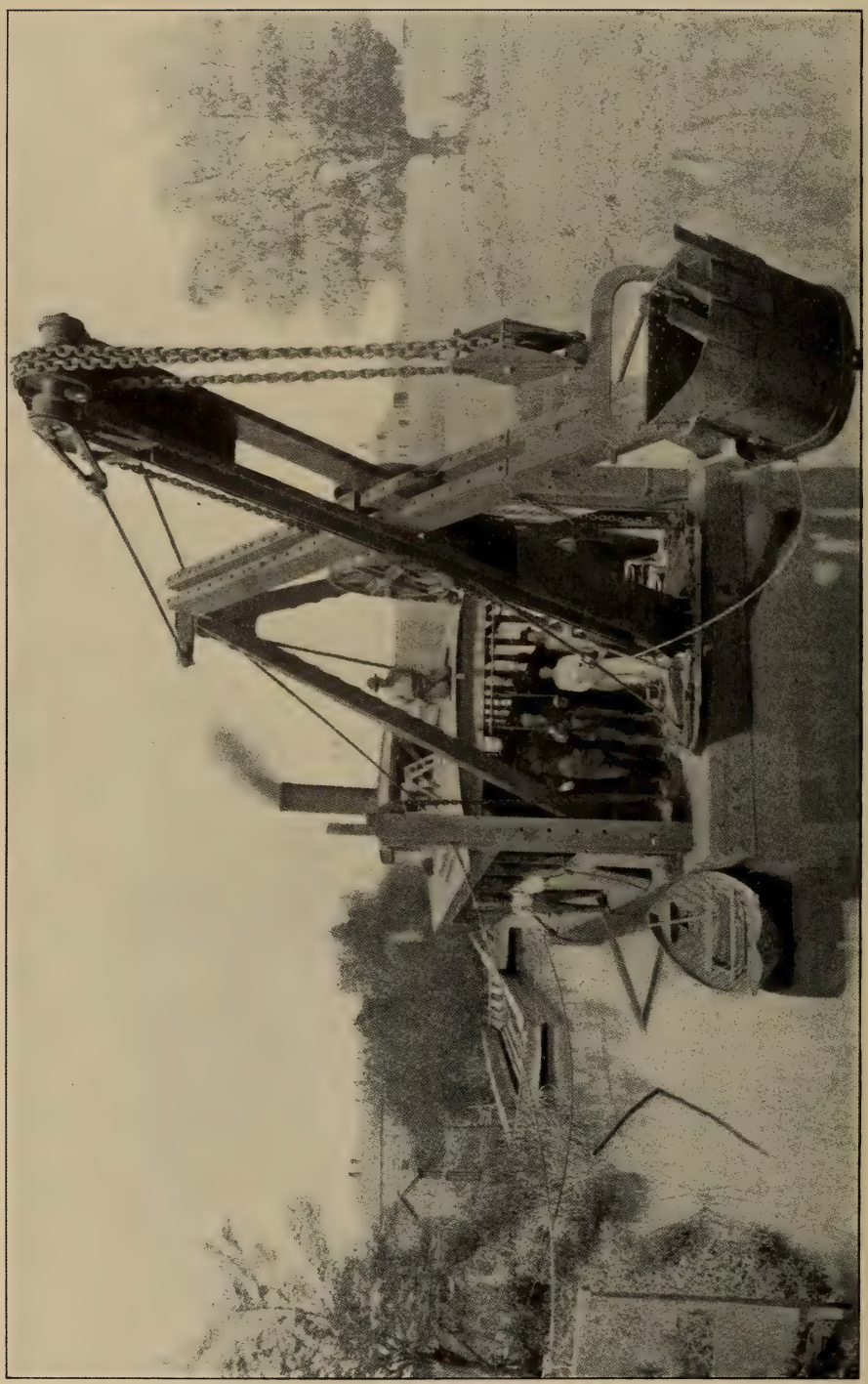
The most serious objection to the bucket-ladder dredger is its waste of power. It is far from being an economical machine in this respect; owing to the necessity of lifting material to a height sufficient to allow it to slide down the shoot by gravitation, work has to be performed nearly 100 per cent. in excess of that required to lift to hopper level. There are many cases where the buckets rise to 30 and 35 feet above the surface of the water before discharging their loads. Shoots have to be pitched at very steep inclinations if discharge is to take place freely. The least inclination for the unassisted transmission of miscellaneous material is about 1 in 4, but 1 in $2\frac{1}{2}$ is often requisite and is certainly desirable. If the flow be assisted by flushing, much flatter slopes may be adopted, the maximum being 1 in 20 for sand. Sticky material, such as clay and mud, requires a fairly steep incline and even then some manual attention must be given from time to time.

It has been stated that the operations of the bucket dredger are limited by consideration of draught. This is undoubtedly true in many cases, but there is a form of dredger specially devised to overcome the difficulty of cutting a way through shoals and projecting banks. A traversing-bucket dredger built by Wm. Simons & Co., Ltd., Renfrew, Scotland, has its ladder supported by a horizontal longitudinal framing capable of being projected in advance of the dredger and is thus enabled to cut her flotation depth through shallow places. Where fresh ground is being opened this consideration is very important and the arrangement is a very convenient one in that it admits of the ladder being entirely removed from the water when out of action, and so made less obstructive to the vessel while voyaging to or from a site.

The navigable qualities of a dredger are not unworthy of attention when there is much traveling to be done, and this leads to the enunciation of the advantage in such cases of having the ladder situated at the stern of the vessel; a normal stem is thereby obtained with good manoeuvring qualities and a better shaped hull for encountering heavy seas.

Dredging vessels have most frequent occasion to exercise navigatory functions when they are of the type termed hopper-dredgers. Ordinary simple dredgers discharge the excavated material into hopper barges ranged alongside. The hopper dredger, on the other hand, is self-contained and complete in itself, being provided not only with apparatus for raising material, but with compartments for its reception. The dredger loads itself, conveys the load to the assigned position, discharges it there and makes the return journey all under her own engine power.

There are, of course, various *pros* and *cons* in reference to this combination of functions. One obvious disadvantage is the discontinuity of dredging operations and the necessity for repeatedly mooring and unmooring. Then again, a hopper dredger may be loaded and at the



A DIPPER DREDGER BUILT BY THE VULCAN IRON WORKS CO., TOLEDO, OHIO, U. S. A.

same time weather bound, so that she is neither able to continue working nor to leave a sheltered position for the open sea in order to discharge. Thus there is loss of time and service.

On the other hand, the combined hopper dredger costs less in initial expenditure and subsequent upkeep than a separate dredger and hopper of equal or even greater capacity. It also monopolizes less water space in restricted areas and so minimizes interference with ordinary commercial navigation. Only one crew is required to carry out all duties; the working expenses are accordingly less, and the time taken up in sea trips may be usefully expended within certain limits, dependent upon the availability of the men's services in overhauling the buckets and their gear, and in effecting minor repairs.

In undertakings of considerable magnitude, where time and interest on capital are factors of the highest importance, it will, on the whole, be found expedient to adopt the separative system with a large fleet of hopper barges in constant attendance upon the dredgers; for though the outlay may be greater, the increased rapidity of execution will compensate for it.

The dipper dredger, with a single fixed bucket at the end of a long lever arm is almost exclusively an American type. It is used mainly on the great lakes of the Northern Continents and on river beds and channels, where the working depth is not very great, seldom exceeding 20 to 22 feet. In such situations it has proved of great utility and it can even be used with effect in places where the draught of water is as much as 30 or 35 feet, but not so advantageously. Mounted on a barge and working either from one end or through a well-hole in the center, the bucket makes a curved upward cut; the contents, after slewing the lever arm, being dropped into a scow or hopper ranged alongside.

One noteworthy feature about the machine, as generally constructed in America, is that the lever arm is made of wood, in preference to steel, which is said to lack the necessary springiness and also to have its rivets work loose. The barge is not generally moored by chains, but is held in position by vertical spuds of timber which are moved as occasion requires. Thus the dipper dredger causes very little obstruction to navigation.

It is not, however, suitable for work in an exposed seaway, and, indeed, is but rarely used for coast work, where greater depths are at present sought than are within the economical capabilities of the appliance.

The concluding section of this article, to appear in the December Number, will be devoted to Grab and Hydraulic Dredgers.

ELECTRIC STORAGE BATTERY ENGINEERING

By J. Lester Woodbridge

A COMPARISON between the storage battery and the dynamo brings out the following points of difference:—The dynamo converts mechanical energy into electric energy, and the input of mechanical energy must necessarily be coincident both in time and rate with the electrical output. With the storage battery, on the other hand, the input as well as the output of energy are electrical; they are never coincident in time and may vary widely as to rate. The battery will supply a widely and rapidly varying demand just as readily as a steady one, while a steam-driven generator under a sudden increase in load may, after the available stored energy is exhausted, fail to respond, owing to the impossibility of quickly varying the rate of steam production. The battery is a storage reservoir of definite capacity; it can respond to a given demand for a given length of time, and must then receive a fresh supply, while the dynamo will give its output so long as the driving power is maintained.

In point of efficiency, the characteristics of the battery are also just the reverse of those of a dynamo driven by any type of heat engine. The battery attains a high efficiency with outputs of short duration, or with those intermittent in character, or at low rates. The dynamo operates with low efficiency under these conditions.

This comparison of characteristics leads at once to a general conclusion as to the character of work which the storage battery is best fitted to perform, and the results which should be sought. Thus the battery may be used to make the time or rate of producing electrical energy more or less independent of the demand, permitting the conditions of production to be predetermined with reference to economy or convenience. The battery may also be used for similarly modifying the conditions of electrical transmission. It should handle those portions of the load which are intermittent in character, of short duration, variable in amount, or subject to more or less uncertainty as to time or magnitude.

The loads falling on electric power plants may be divided with respect to their characteristics into two general classes, viz.:—those which fluctuate rapidly over wide ranges, from moment to moment, and those whose changes are gradual, taking place from hour to hour. In the first class are the loads due to electric railway systems, shops driven by individual motors, rolling mills, electric elevators, and hoists. In the second class are electric lighting loads. In many instances the two characteristics are combined, as in large urban railway systems whose load curves exhibit not only momentary fluctuations, but regular morning and evening peaks, with a base line of two or three hours and a maximum sustained for half an hour or more. In office-building plants a lighting load is frequently found with its five-o'clock peak combined with the fluctuating load of electric elevators.

These two characters of load variation have given rise to two broadly different methods of battery control and regulation, viz.—booster control and end-cell control. The former is largely automatic and is employed with rapidly fluctuating loads; the latter almost invariably involves

manual operation, and is confined to lighting service, with slowly varying demands. Before taking up the details of these two methods of battery control, we will consider the electric characteristics of the storage battery cell,—the "lead-lead" cell, this being the type of battery now in commercial use.

On open circuit, a storage battery cell has an electromotive force of approximately 2.08 volts. This open-circuit voltage varies but little with the state of charge, provided the cell has been allowed to stand on open circuit for some time. The open-circuit voltage of a cell is, therefore, of very little use as indicating its state of charge.

On discharge, the voltage characteristic of the cell is what is termed "drooping"; that is, its terminal voltage falls with increase in output, and the immediate change in terminal voltage, which is that due to the internal resistance of the cell, is proportional to the change of current output. With a reversal of current to the charging direction, the terminal voltage will rise, the immediate change of voltage being proportional to the change of current in a like ratio. The amount of this instantaneous change of voltage may be anywhere from 5 to 10 per cent. of the open-circuit voltage with a change of current equal to the one-hour discharge rate of the cell, depending upon its temperature, state of charge, strength of electrolyte, the design of the plates, etc. Of these factors, temperature has the most marked effect, the internal resistance of a cell increasing appreciably with a reduction of temperature.

In addition to this immediate drop in voltage which takes place the instant the discharge begins, a further drop occurs if the discharge is continued for any length of time, due to what is termed "polarization" of the plates. A considerable proportion of the polarization drop occurs within the first few seconds after the discharge begins, and for all practical purposes it may be considered as a part of the ohmic drop, to which it may add from 20 to 30 per cent. Beyond this, polarization may be neglected in dealing with rapidly fluctuating loads.

Polarization acts in the opposite direction with a charging current, causing a further rise of voltage, in addition to that due to internal resistance, if the charging current is continued. If the battery is fully charged, this polarization with charge becomes excessive, owing to the rapid formation of gas on the plates which the active material cannot absorb. If, therefore, a minimum voltage variation is desired, or an accurate adjustment of auxiliary apparatus to the battery characteristic is sought, with a rapidly fluctuating load, it is necessary to operate the battery not quite fully charged.

When a continuous discharge is taken from a cell, the voltage drops during the first few seconds as previously stated, and then becomes practically constant, falling very gradually as the discharge progresses, until, at the end of the discharge, it again falls off rapidly, dropping to zero if the discharge is continued by reducing the external resistance to zero. In practice, the discharge is limited to the critical point where the voltage curve begins to drop off rapidly, as the capacity beyond this point is of no practical value. The voltage at this critical point varies with the rate of discharge and also with the temperature. It is quite customary to discharge down to 1.6 volts per cell at the higher rates, or to 1.7 volts per cell at the lower rates.

During charge at the normal or eight-hour rate, the voltage rises gradually from about 2.2 to 2.3 volts, and then toward the end of charge, rises more rapidly, the curve rounding off to a maximum when the cell is fully charged. This maximum is usually about 2.5 volts, but will vary from this, depending on the temperature, rate of charge, age of plates, etc., so that, although 2.5 may be

considered the ordinary final voltage on charge with charging current flowing at the eight-hour rate, this voltage cannot be taken as a reliable indication that a cell is fully charged. To insure that a cell is fully charged, the voltage must reach its maximum, whatever that may be, with the charging rate constant.

The capacity characteristics of the storage battery also present certain peculiarities which often must be considered in determining the details of a battery installation. The capacity of a cell, in ampere-hours, varies with its temperature and with its rate of discharge.

The one-hour discharge rate is becoming the standard, in specifying battery capacity, particularly when a battery is to be used for high-rate discharge. When the normal rate is mentioned, one-fourth of the one-hour rate is meant. A cell will ordinarily maintain a discharge at the normal rate for from seven to eight hours. This rate is, therefore, frequently referred to as the eight-hour rate, and at this rate, the capacity of a cell in ampere-hours is nearly double its capacity at the one-hour rate. It is, however, often found advisable where a battery is installed for high-rate discharge work, and the low-rate capacity is not required, to use plates which will give only six to seven hours at the normal rate (one-fourth the one-hour rate).

It must not be inferred that the reduction in ampere-hour capacity of a battery at high discharge rates affects its efficiency similarly. After one hour discharge at the one-hour rate, a battery will require only one-half the amount of charge that would be necessary to fully charge it after an eight-hour discharge at normal rate; in fact, at the end of the one-hour discharge, the battery is only half discharged, and although no further output is available at that rate, the discharge may be continued by reducing the rate, and the balance of its capacity be thus obtained.

Temperature has an appreciable effect on the capacity of a cell, the capacity increasing with rise of temperature, and vice versa.

The electrolyte, consisting of sulphuric acid diluted to a specific gravity of about 1.21 (usually referred to as 1210 degrees) offers the only practical means for determining the state of charge of a battery under all conditions. As the plates discharge, the acid in the electrolyte combines with the active material and is thus withdrawn from the solution, the electrolyte becoming weaker. When the plates are recharged, the acid is again set free and the electrolyte becomes stronger. The amount of acid thus absorbed or set free is exactly proportional to the capacity in ampere-hours given out or received by the plates.

If, therefore, the maximum specific gravity of the electrolyte in a cell, when fully charged, is known, as well as the minimum specific gravity when completely discharged, the state of charge at any intermediate point may be determined by observing the specific gravity. The range of the specific gravity between full charge and complete discharge is from 1.210 down to about 1.170.

This range is considerably reduced where provision for future increase in capacity is made by providing tanks or jars larger than necessary for the number of plates first installed, thus involving an excessive volume of electrolyte. In such cases it is good practice in one cell of the battery—the pilot cell—to block off the excess space at the end in some convenient manner, so that the amount of electrolyte affected by charge and discharge shall be normal, thus producing a maximum range of specific gravity.

The specific gravity of the electrolyte is also affected by temperature and by evaporation. In order to obtain the true reading, a correction for temperature must be applied and the cell kept filled to a constant height by the addition of water. Hydrometers, which are self-correcting, as regards

temperature, are now made, and an automatic device is also supplied for keeping the height of the electrolyte constant.

Having touched upon the characteristics of the battery itself, we will next consider the auxiliary apparatus employed for its control. The two distinctive methods of battery control, namely, end cell regulation and booster regulation, have already been mentioned, and these give rise to two classes of auxiliary apparatus.

End-cell control is effected by an end-cell switch, by means of which the number of cells in circuit may be varied. This switch consists of a number of contacts arranged consecutively, each being connected to a point in the battery between a pair of adjacent end cells. There is also a traveling contact arm or brush, which, while maintaining connection with the supply circuit, may be shifted from point to point, thus cutting in or out the end cells, one by one. The traveling contact arm is provided with an auxiliary contact connected to the main arm by a suitable resistance, and arranged in such a way that in passing from point to point the battery circuit is not opened nor is the cell which is connected between the two points short-circuited, except through the auxiliary contact and resistance, which prevents excessive current.

In small plants, the end-cell switch is mounted directly on the switchboard, and is operated by hand. In large central stations, where the conductors from the end cells to the switches are heavy and their length must be reduced to a minimum, the end-cell switch is installed just outside the battery room wall, but as close as possible to the end cells, and is operated by means of a motor with distant control from the switchboard. In this case the moving contact is a heavy laminated copper brush, provided with auxiliary carbon contacts. The brush is moved by a motor-driven screw, and the apparatus is so designed that the brush will stop automatically in full contact with each point, and cannot be stopped by the switchboard operator in any intermediate position. An electric indicator is mounted on the switchboard, which shows the position of the brush, and thus the number of cells in circuit.

With end-cell switch control the total number of cells in a battery is determined by the bus voltage to be maintained, and the minimum voltage per cell to which the discharge is to be carried; thus if the bus pressure is 110 volts, and the cells are liable to be discharged down to 1.6 volts per cell, a total of 69 cells will be required. The number of cells in the main battery, that is, the minimum number that ever will be required, is determined by the maximum cell voltage when the battery is to be connected to the bus. This may be as high as 2.1 volts if the battery is to be connected to the bus without appreciable discharge, so that with 110 volts at the bus, 52 cells would be required, calling for 17 end cells. In many cases the bus voltage is raised just at the time when the battery is to discharge at its maximum rate during the peak, in order to compensate for feeder drop. This will call for an additional number of end cells, the main battery remaining the same.

In plants of this character, where end-cell regulation is employed on the discharge, the voltage necessary for charge is considerably higher than the bus voltage, and a charging booster is installed which supplements the bus voltage for this purpose. This booster is a shunt-wound machine, usually motor driven. It is ordinarily made of sufficient capacity to charge the battery at its five-hour rate up to 2.5 volts per cell.

Booster regulation is adopted where automatic control for rapidly fluctuating service is desired. Technically, a booster is a dynamo-electric machine whose electromotive force is employed to supplement some other electromotive force. In storage bat-

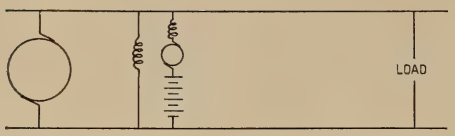


FIG. 1.—COMPOUND BOOSTER

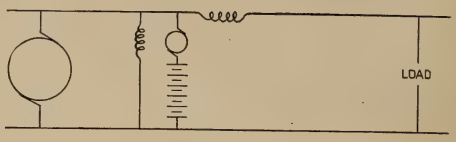


FIG. 2.—DIFFERENTIAL BOOSTER WITHOUT INSIDE COIL

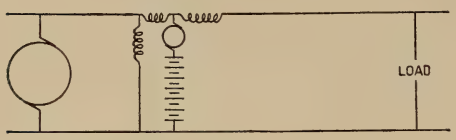


FIG. 3.—DIFFERENTIAL BOOSTER WITH INSIDE COIL

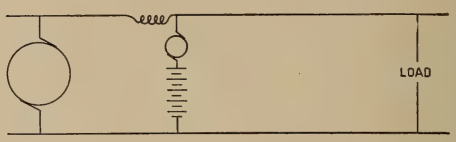


FIG. 4.—BOOSTER WITH COIL IN GENERATOR CIRCUIT

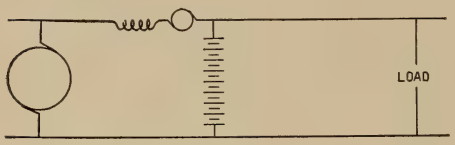


FIG. 5.—CONSTANT CURRENT BOOSTER

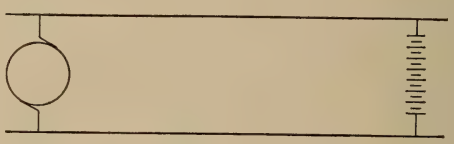


FIG. 6.—FLOATING LINE BATTERY

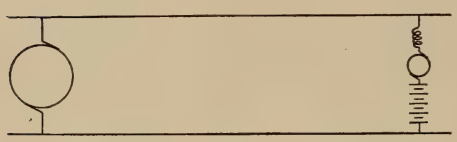


FIG 7.—LINE BATTERY WITH COMPOUND BOOSTER

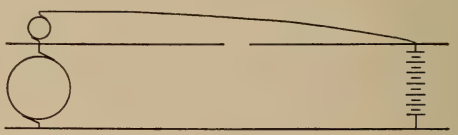


FIG. 8.—LINE BATTERY WITH BOOSTER FEEDER

tery work we have two electromotive forces,—that of the battery and that of the system with which it is operating. The booster is invariably connected so that it may be considered as supplementing, positively or negatively, either of them.

A battery connected to an electric system, in parallel with other sources of electric current, can be made to discharge, or have its discharge rate increased, only by reducing the potential across its terminals. Conversely, it may be made to take a charge, or have its charging rate increased, only by increasing the potential across its terminals. The function of the booster, in automatic load regulation, is to produce these variations of potential automatically in response to changes of load, thus compelling the battery to respond to such changes. The desired variations of booster voltage are produced by a field winding on the machine which, until recently, has invariably been connected directly into one of the three circuits involved; namely, (1) the battery circuit; (2) the outside supply circuit; and (3) the generator circuit.

In some comparatively recent developments in booster control, the actuating coil, instead of being wound directly on the booster fields, is arranged to act indirectly by means of intermediate regulating apparatus. This, however, does not affect the underlying principle, and the three possible locations of the actuating coil, whether acting directly or indirectly on the booster field strength, give rise to three different types of boosters.

The simplest type is that with the booster field coil in the battery circuit. This is commonly called the "straight compound" booster. See

Fig. 1. In this type of installation, the booster alone cannot cause the battery to charge and discharge, since it depends upon the current in the battery circuit to actuate it. It is necessary, therefore, to provide some outside cause to produce battery discharge or charge, and the booster will then become a factor in determining the amount of such charge or discharge. As already mentioned, the only way to cause a battery to discharge is to lower its terminal voltage.

If, therefore, a battery with straight compound booster is to charge and discharge with decrease or increase, respectively, of load on the system, thus compensating for changes of load, the characteristic of the system at the point where the battery is connected must be a drooping one; that is, the voltage must drop with increase of load, and vice versa. Having thus provided a cause for battery action, the compound booster will increase the scope and effectiveness of such action and reduce the variation of voltage otherwise necessary to produce the desired range of charge and discharge. Thus a drop in voltage, which, without a booster, might cause the battery to discharge 50 amperes, might, in conjunction with a compound booster, cause the same battery to discharge 500 amperes. Or, conversely, if a drop of 50 volts were necessary to produce a discharge of 500 amperes without the booster, the same discharge might be produced by a drop of 5 volts with a compound booster in series with the battery.

This system is therefore applicable at a power house in connection with shunt-wound generators having a decidedly drooping characteristic, or at some point on the system distant from the power house, where the line-drop is appreciable. In addition to the regulating or series coil on this type of booster, a shunt winding controlled by a rheostat is also provided for the purpose of manual adjustment. Hence the term "compound" booster.

The second type of booster, in which the regulating coil is located in the outside circuit and thus carries the total current demand, is usually referred to as the differential booster. See Fig. 2. The booster voltage in this case varies directly with changes of load, regardless of battery charge or discharge. There is thus introduced into the battery circuit a positive cause compelling the battery to charge or discharge in response to the fluctuations of demand, and it is not necessary to depend upon any special characteristic of the system. At some particular value of the demand, it is desired that the generator shall carry the entire load, the battery neither charging nor discharging. As it is customary to install such a number of cells that when neither charging nor discharging the battery voltage shall be equal to the bus voltage, the voltage of the booster must under such conditions be zero. To effect this result, a shunt-field winding is provided, which opposes the action of the regulating or series coil, and may be adjusted by a hand-operated rheostat so as to exactly neutralize the effect of that coil when carrying any predetermined amount of current. Fluctuations of demand above or below this predetermined amount will then cause the booster voltage to vary on either side of zero, the effect of the shunt field remaining constant. The term "differential" as applied to this type of booster refers to the opposing action of these two coils. It is customary to design the differential booster with a third field coil connected in the generator circuit, as a corrective coil. See Fig. 3. If the adjustment of the outside coil which carries the total current demand is imperfect, permitting fluctuations to fall on the generator, this inside coil in the generator circuit will partially correct the defect.

The third type of booster comprising those in which the regulating coil is located in the generator circuit, is again divided into two sub-classes, ac-

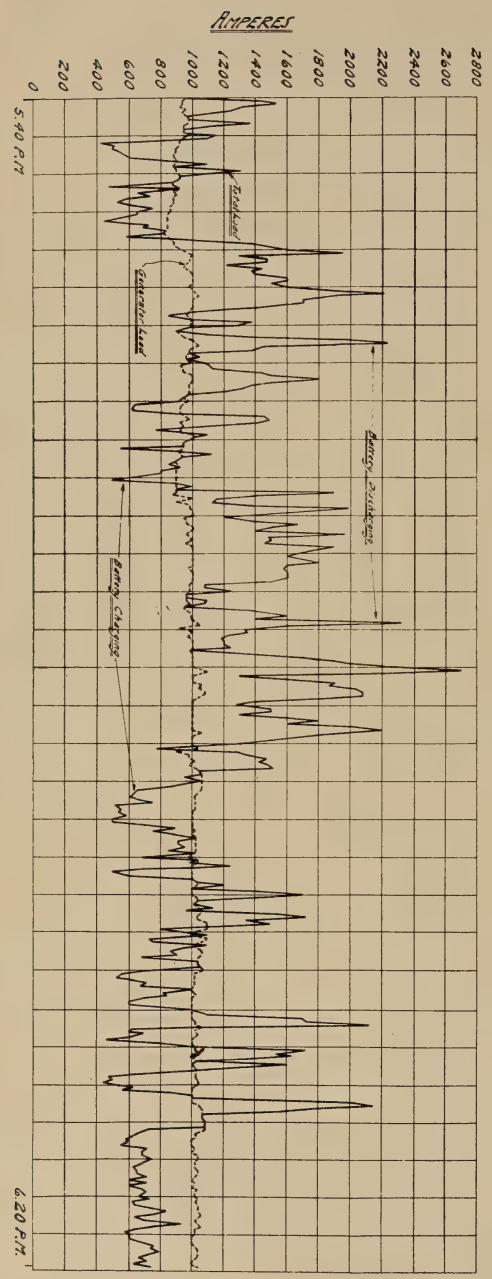


FIG. 9.—A BATTERY FOR A FLUCTUATING RAILWAY LOAD

cording to the location of the booster armature. While the regulating coil is, in both classes, located in the generator circuit, in the first class the armature is located in the battery circuit as in Fig. 4, whereas in the second class the armature is located in the generator circuit, the conductors for the supply circuit being taken directly from the battery terminals as in Fig. 5. This second class comprises the so-called "constant current" booster, the armature carrying the practically constant current supplied by the generator, as distinguished from the fluctuating currents carried by other types; its use is confined to cases where the fluctuating voltage across the battery terminals is permissible on the supply circuit.

Both of these sub-classes depend for their operation upon permitting a certain percentage of the load fluctuations to get back to the generator, thus passing through the regulating coil, whose action on the booster is to cause the battery to take the balance of the fluctuations. As it is usually desired to reduce the fluctuations on the generator within narrow limits, it is quite usual, with boosters of this type, especially those of the first class mentioned, to interpose some multiplying device between the controlling coil and the booster field. One such device consists of a regulator in which the coil is a solenoid acting on a soft iron core, the core being suspended from a lever which bears upon piles of carbon discs. The variations of pressure produced on the carbon piles by the small changes of current passing through the solenoid varies their contact resistance, and by suitable connections, similar to those of a Wheatstone bridge, these variations of resistance act on the booster field.

In another such multiplying arrangement, the operating coil is wound on the field of an exciter, the current in this coil producing an exciter voltage approximately equal to that of the bus. The booster field is connected between the exciter and the bus, and variations of current in the regulating coil cause fluctuations of the exciter voltage above or below that of the bus, thus varying the booster field.

The general results sought by the operation of a battery in connection with an electric lighting or power station are:—(1) Improved efficiency; (2) reduced depreciation and maintenance; (3) voltage regulation; (4) emergency service.

Improved efficiency is secured by throwing on the battery those portions of the load which can be handled with least efficiency by other apparatus. Thus in an electric railway power house, subject to loads varying from moment to moment, the battery takes the fluctuations and the generators carry the average demand. The effect of such an arrangement on the efficiency of operation is two-fold. In the first place, instead of being obliged to operate sufficient machinery to generate the maximum current demand, it is necessary to generate only the average current demand, thus permitting a part of the generating units to be shut down. The constant losses in these machines, due to friction, field excitation, etc., are thus obviated, while the units that are in operation are loaded to their point of maximum efficiency. In the second place, the substitution of a steady load for a fluctuating one maintains the steam cut-off at the most efficient point, instead of varying constantly from the minimum to the maximum the governor will permit, with the accompanying changes of temperature in the cylinders and consequent excessive cylinder condensation.

When there exists a sustained peak, as in most lighting plants and in the larger railway systems, the battery can economically handle such a peak for two to three hours. In such a case, not only is an equivalent capacity in generating machinery shut down during those hours, but the banking of boilers throughout the balance of the twenty-four hours, for service on the peak may be dispensed with and a material increase in boiler-room economy effected. Not only does the battery permit shutting down the machinery which otherwise would

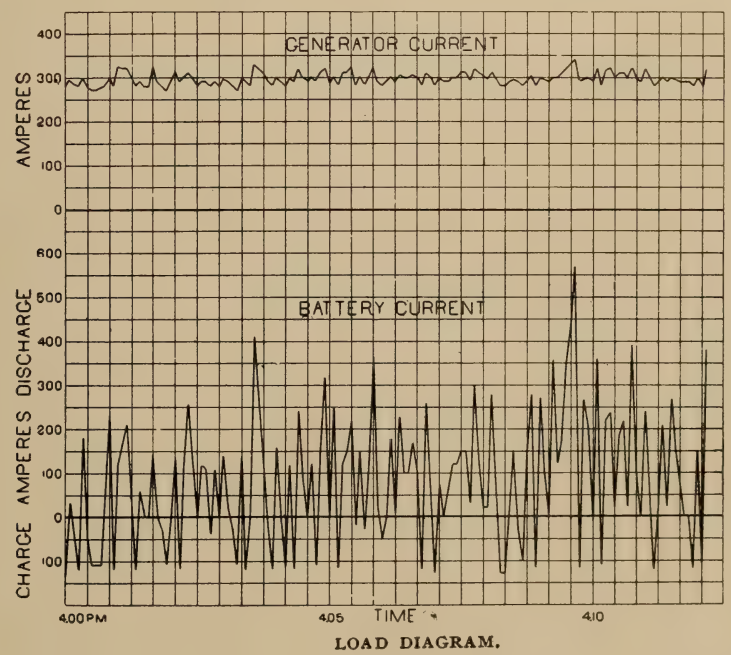


FIG. 10.—FLUCTUATIONS DUE TO ELECTRIC ELEVATOR SERVICE IN A TALL BUILDING

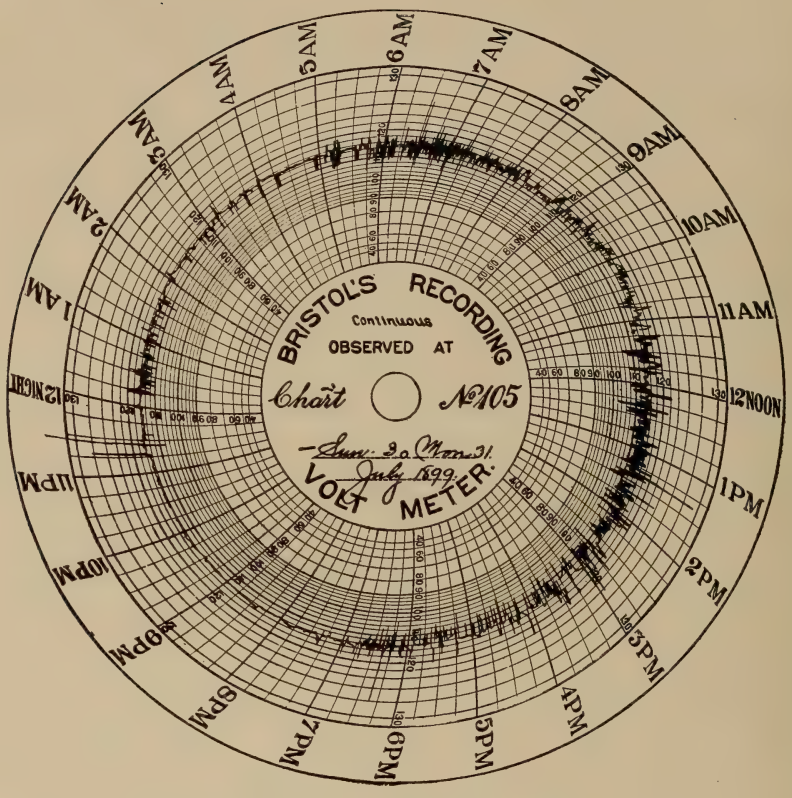


FIG. 11.—VOLTAGE READINGS BEFORE USING A STORAGE BATTERY

be required for peaks and fluctuations, but in many cases it obviates the necessity of keeping a certain capacity in generating machinery and boilers in operation, prepared to meet sudden and unexpected demands which might possibly occur.

The reduction in maintenance and depreciation is the result of shutting down a certain amount of machinery, as well as the substitution of a steady load for a fluctuating one. The possibility of immediately shutting down a unit as soon as indications of trouble appear, the load being temporarily carried by the battery, instead of by the disabled unit until another one be put into service, also reduces maintenance and depreciation, as the difficulty in the meanwhile is liable to become far more serious.

Voltage regulation is of the greatest importance in connection with electric lighting service, and it is standard practice in nearly all direct-current lighting stations to keep a battery floating on the lighting bus at all times, thus maintaining constant voltage and eliminating the disagreeable flickers at the lamps due to sudden changes in the demand. In many cases, current for lighting and railway service is supplied from the same machinery, and the voltage on the lighting system is maintained constant only by the operation of a battery to care for the fluctuations of the railway load.

Voltage regulation is also accomplished by a battery located at a distance from the power house to relieve the system of the fluctuations of pressure due to line-drop under variable load. For this purpose the floating voltage of the battery should be equal to the average voltage at

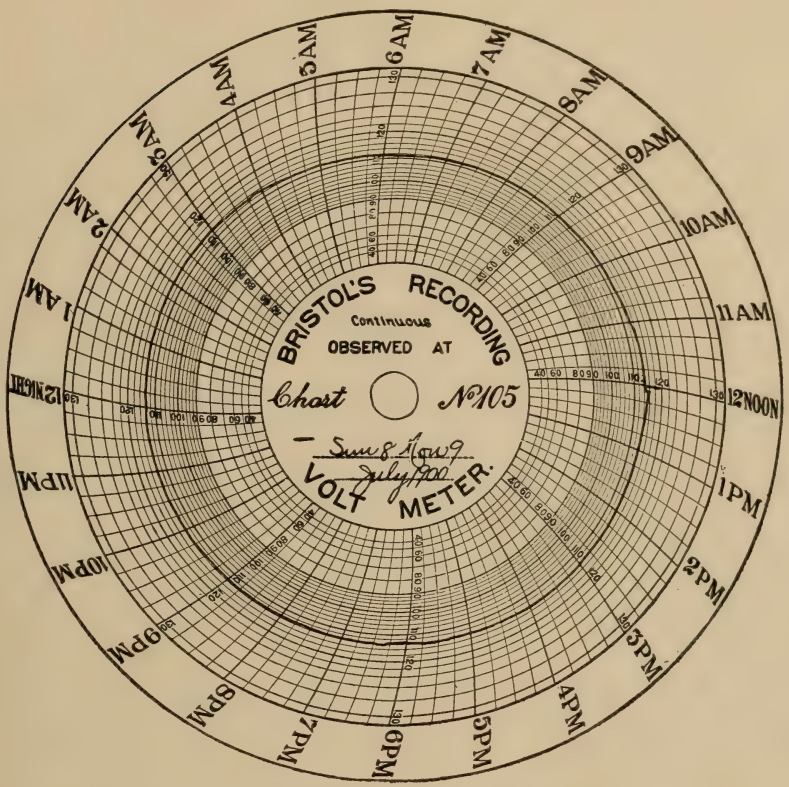


FIG. 12.—VOLTAGE READINGS AFTER PUTTING IN A STORAGE BATTERY

the point where it is located. The battery will then receive as much charge as discharge, and will always remain in the same state of charge. Such a battery also improves the efficiency of transmission, for the mean square of a variable quantity is always greater than the square of its mean value, and the C^2R losses in a conductor follow the same law.

Line batteries of small capacity are generally installed without a battery booster, as in Fig. 6. With larger batteries of this character, where more constant voltage is desired, or peak work is to be done, and where the conductors between the power house and battery are so heavy that the line-drop is insufficient to call on the battery for its full output, a compound booster is generally installed as in Fig. 7. Such line batteries, whether of large or small capacity, and whether with or without a battery booster, are frequently fed by a "booster" feeder, a shunt-wound booster being used at the power house to raise and control the voltage of this feeder. See Fig. 8.

In all classes of service, one of the most important, and in some cases the most important function of the battery is as an emergency reserve. For such service its inherent characteristics render it ideal. Consisting as it does of a multitude of similar units, (the plates,) no one of which is essential to the operation of the rest, it is not subject to sudden breakdown, but may be called upon in an emergency at an instant's notice for its available capacity at overload rates far exceeding those which would cripple any other class of apparatus. The storage battery has on this account become an essential part of every in-

stallation where continuity of service is of paramount importance.

The accompanying load diagrams illustrate the several uses of the storage battery previously mentioned. Fig. 9 shows how a battery handles the fluctuations of a railway load caused by heavy interurban service. Fig. 10 shows the operation of a battery handling the fluctuations due to electric elevator service in an office building. Figs. 11 and 12 show the effect produced by a battery on the voltage of an electric light plant; the voltmeter charts, taken before and after the battery installation, clearly indicate the elimination of voltage fluctuations effected by the battery.

A few words on the general care of storage batteries may not be amiss. While the detailed instructions for the proper handling of a battery will vary more or less with the class of service, a few general principles will apply to all cases. The amount of attention which a battery requires is comparatively small, but is as important to the battery as oiling is to an engine. The electrolyte must be kept above the tops of the plates by the addition of pure water from time to time to replace evaporation. Prolonged and repeated overcharging, that is, after the battery is full, should be most carefully avoided. About once a week it is desirable to slightly overcharge the battery, the charging current being continued for about an hour after the maximum specific gravity is reached. At other times the charging should be stopped just short of the maximum point.

Over-discharging, that is, continuing the discharge after the normal stopping point has been reached, should be avoided in regular service.

The battery should not be allowed to stand for a considerable length of time in a discharged condition, but should be recharged as soon as practicable. This applies not only to the battery as a whole, but to the individual cells. If some of the cells, by reason of an accidental short-circuit, become discharged, the cause should be removed as promptly as possible, and the cells brought back to their proper state. A slight or partial short-circuit may occur by the lodging of foreign material between the plates in a cell; this will gradually bring the cell to a lower state of charge than the others in the battery. To detect cases of this kind it is advisable to take specific gravity readings of all the cells once a week. If these readings show that a cell has fallen off below the others, the cause should be sought out and removed, and usually the weekly overcharge will bring the cell back to its normal state of charge.

A recording voltmeter which will give a continuous record of the voltage at the battery terminals is of great assistance in insuring the proper handling of the battery. Such a record will indicate the character of service to which the battery has been subjected; will show whether the charge has been stopped at the right point, and by giving the average at the battery terminals for each twenty-four hours will enable the operator to determine whether the battery is being overcharged, or the reverse. A recording hydrometer for use in connection with the pilot cell has also recently been developed. The hydrometer charts in connection with the recording voltmeter charts will give a very complete history of the battery operation from day to day.

Current Topics

Once more we have to chronicle the completion of the largest ship ever built. This time it is the new twin-screw steamer "Amerika," of the Hamburg-American Line, which left Hamburg for New York on her maiden voyage early last month and arrived at the latter port on October 19. She exceeds the mammoth "Baltic" of the White Star Line by 2000 tons in displacement, having 42,000 tons to her credit instead of the "Baltic's" 40,000 tons, though her length is less,—only 690 feet as against 726. The "Amerika's" beam, however, is 77 feet against the 75 feet of her rival, and as to her depth,—that is perhaps most strikingly illustrated by the fact that an electric passenger elevator serves the different decks. From the lowest saloon deck to the boat deck represents the height of an average five-story house. Quadruple-expansion engines of 17,500 I. H. P. propel the ship at a speed which will make the trip between New York and Hamburg about nine days long. The "Amerika" thus does not belong to the "flier" class, but what she lacks in this respect has been probably more than compensated for in another way by her superior, indeed luxurious, appointments. These include an "à la carte" restaurant,—an adjunct to ocean travel which will be appreciated by even hardened old travelers; a number of special suites of rooms, the Imperial suites as they have been named, which exceed in all respects anything previously attempted on shipboard; stateroom telephone service; Marconi wireless telegraph equipment; a nursery for the rising generation; hydropathic and electric baths and massage facilities; a florist's shop, and a well-fitted-up gymnasium. A submarine sound signalling system is among the safety devices of the ship's equipment, among which, too, the automatic closing of water-tight bulkhead doors should be mentioned. This latter is accomplished from the bridge by electrical means. The ship has accommodations for 3057 passengers. Her crew complement being 520, she will thus, when full, have close on 3600 persons on board. A distinctly up-to-date feature of the "Amerika" is that she will have a "fourth class." In the first-class division she will have accommodations for 507, and in the second for 284. Then comes a class entitled "intermediate," the number here provided for being 230; while, lastly, there is a "third" class depart-

ment, which will accommodate no less than 2036. One especial point to be noted in connection with the steerage passengers is that they will never find themselves berthed below the lower deck. Moreover, they will, at certain times of the day, have the use of one of the upper decks aft.

THE great problem in iron making in the future will be to find sufficient iron ore for the world's needs. This is the opinion which has long been held by far-sighted iron and steel men, and has more recently been again expressed by Mr. John Fritz, the veteran metallurgical engineer, in an interview printed in the "Manufacturer's Record." Some years ago, according to Mr. Fritz, he was interested with Mr. Samuel Thomas, of Pennsylvania, in the Pioneer Iron Company, of Birmingham, Alabama, U. S. A., which was afterwards sold to the Republic Iron & Steel Company. In that company Mr. Thomas pursued the policy which he had so wisely carried out in his own operations in Pennsylvania, of buying iron ore, rather than of using his own supplies, whenever he could do so to advantage. In his ironmaking operations, extending over so many years in Pennsylvania, he was always a buyer of ore, whenever prices were favourable, in order to preserve for the future his own supply, and the fact that his company has lived and prospered and is justified in building new furnaces in a section of Pennsylvania where nearly all other iron companies have ceased operation is proof of the wisdom of his policy.

IN a recent presidential address before the American Society of Civil Engineers Mr. C. C. Schneider declared that the competitive system by which bridge-building companies supply their own designs for bridgework has had its day in America. He advocated, instead, a system which appears to be practically identical with established British practice, the designs being prepared by a consulting engineer, and on these designs the bridge builders are then asked to tender. Mr. Schneider held that plans for bridges and other structures, on the safety of which the lives of human beings depend, should be "designed" and not "manufactured." It is curious to note, says "Engineering" as to this, that whilst, according to Mr. Schneider, the Americans are approaching British methods in this particular, British practice is, on the other hand, coming into line with that of America, since it is certain that more bridges are nowadays erected in Great Britain to the contractor's designs than has up till recently been common. Probably all will agree that in the case of very large and difficult structures there are advantages in having the designs prepared by a first-class consulting engineer. The necessity for this is, however, by no means so obvious in the case of small-span bridges, where a reputable contractor will be quite capable of erecting a thoroughly substantial structure without outside assistance.

INVISIBLE platinum wire is the subject of an interesting article by S. D. V. Burr in a recent issue of "The Iron Age." Some thirty-five years ago, according to Mr. Burr, the late Henry F. Read made several yards of platinum wire so fine that when wound around a white card it could not be seen except by those having exceptionally good eyes. It could be felt, and the shadow cast by it upon the card could be seen, so that its presence was manifest. Its exact diameter was not known, and although this could easily have been calculated, it was not thought necessary; the wire could not be seen, *ergo,* it must be very fine, and it certainly was fine enough for the use to which it was to be put. That was sufficient.

The manner of drawing the wire was exceedingly simple. A steel die was first made, the hole being as small as it could conveniently be drilled and polished. Diamonds and rubies were then used for wire drawing, but the steel was easier to handle and answered the purpose just as well. Platinum was then drawn through the die as a first step. A length of the platinum wire was then put in a tube of silver which was passed through the die. A length of the composite wire was again incased in silver and the drawing repeated. After the wire had been passed through the die a sufficient number of times the silver was removed with acid and the invisible platinum wire resulted. At first the drawing was done by hand, but the starts, stops and jerks of this method were found to have a tendency to break the wire, especially when it had become quite fine. This trouble was overcome by providing a little draw bench having a pinion and gear for doing the pulling; the strain was then constant and steady, yet, even with this, only comparatively short lengths could be drawn. A wire 3 feet long was thought to be a very successful performance.

The wire was intended for use in making the cross-wires in transits, telescopes and optical instruments of like character. The animal fibers employed for this purpose caused considerable inconvenience, principally for the reason that they were affected by slight changes in the humidity of the atmosphere. It was thought the metal would overcome these and other difficulties, but the wire itself possessed defects which were of a far more serious nature and prevented its employment for this purpose. It could be readily inserted and adjusted, and once placed in position it could be relied upon to stay there; but its disadvantages far more than counterbalanced these good points. The prohibitive defect arose from the fact that its surface was too bright. The instrument maker demanded a cross-wire that was a dead black—one that was shiny would ruin the accuracy of his instrument. Fibers could be dyed; the metal could not be coloured. The wire manufacturer found he had produced an article which could not be used for the specific purpose for which it had been made, and for which there was no demand in any other direction. He also found that a comparatively few yards of wire would stock the market, as far as the instrument men were interested, and that there was no other demand for invisible wire. He had not produced a commercial article, but he had made a beautiful experiment.

The widening use of tungsten and the consequent rapidly increasing demand have led to high and still rising prices and to energetic prospecting in many parts of the world. The principal use of tungsten at the present time, according to "The Engineering and Mining Journal," is in the production of what is called self-hardening steel. For this purpose it is added in the proportion of from 5 to 8 per cent. When used in tool steel the alloy retains its hardness even when heated to temperatures which would quickly destroy the temper of ordinary high-carbon steel. Tungsten steel may be used as armour plates. An alloy of 35 per cent. tungsten and 65 per cent. steel will make a shell for lead bullets of much higher penetrating power than ordinary lead. Metallic aluminium can be advantageously hardened with tungsten, its resistance to oxidation making it much superior to copper. A small percentage of tungsten will also greatly increase the carrying power of spring steel. The steel used in the manufacture of permanent magnets for electrical meters contains from 5 to 6 per cent. of tungsten. Tungsten steel is also used for the sounding plates of

pianos. Among the minor uses, tungsten compounds are frequently employed to make vegetable tissues incombustible, and they enter into the composition of the fluoroscope for X-ray observations. Metallic tungsten has a specific gravity of 18.7; it is practically free from carbon, and may be welded and filed like iron. It is found in the market as a metal of from 95 to 99 per cent. purity, or alloyed with iron in the proportion of 37 per cent. and described as "ferro-tungsten." The world's yearly consumption at present amounts to something like 700 or 800 tons. The chief sources of tungsten are wolframite, hübnerite, and scheelite. Often the ore contains not more than 5 to 8 per cent. of metallic tungsten. To be marketable it must be brought to an average of 50 to 70 per cent. tungstic acid, the unit basis of selling prices.

THE influence of fatigue on workmen and the part it plays in relation to accidents have lately formed the subject of an exhaustive inquiry on the part of M. Imbert, professor at the Montpellier Faculty of Medicine, and M. Mestre, a factory inspector in the Department of the Hérault. From their united investigations, as told in the Paris correspondence of the London "Globe," important indications have been obtained relating to the physiological conditions during the hours of labour. These observations have shown that the number of accidents increases progressively hour by hour during the first half day; that after the rest at midday the number of accidents is notably less than in the last hour of the forenoon; that in the course of the second half day accidents again become, from hour to hour, progressively more numerous, and that the maximum number of accidents toward the end of the second half day is notably higher than the corresponding maximum in the morning. The influence of the workmen's fatigue on the production of accidents stands out clearly from these observations, and it is easy to understand how this comes about when it is remembered that with fatigue the attention readily diminishes and disappears. The conclusion, therefore, is that in order to produce a diminution in the number of accidents it would be sufficient to intercalate in the middle of each half day of work a period of repose, naturally not so long as that at midday, but the length of which remains to be determined. In fact, one would only have to apply to the manual labour of adults the measures which for a long time have been put into practice for children as regards their intellectual labour.

IN a recent enumeration of the great tunnels of the world, beginning with the 12½-mile Simplon tunnel, the latest to be completed, the fact was briefly noted and is worth repeating that the greatest tunnel of them all,—on paper,—is the tunnel under the English Channel, projected in 1856, actually commenced ten years later, and vetoed in 1883 by a select committee of members of Parliament. Another tunnel, much discussed, but never carried out, was that planned to connect Scotland with Ireland.

A NOVEL use of cement is mentioned in "The Cement Age," being in connection with repairing a hole in the hull of a British steamer. Recently at Newport News, a steamer "Albuera" went into dry dock for repairs, and it was discovered that a large hole through her bow, received through contact with a sharp pointed rock in the Straits of Magellan, had been temporarily filled with a mass of timber, canvas, ballast rock and Portland cement, and that this temporary filling enabled the vessel, without further damage, to make her port. The

cement was so strong that the chief of the hull construction at the dry dock found that it would take six weeks to chip it out with the ordinary appliances, and finally he was compelled to put in small charges of dynamite, and after three days of blasting the cement was at last removed, without injury to the vessel upon the dry dock.

WALTER H. WHITESIDE

The New President of the Allis-Chalmers Company

A BIOGRAPHICAL SKETCH

THE recent election of Walter H. Whiteside to the presidency of the Allis-Chalmers Company lends especial interest to the excellent portrait of him, printed in this issue.

Mr. Whiteside's rapid rise from one position of responsibility to another shows how soon after becoming familiar with the company's manifold activities his executive ability began to manifest itself. His career previous to his joining the Allis-Chalmers interests is an illustration of steady progress, of vigorous and clear-sighted management resulting in success, and of complex problems met and solved both rapidly and effectively. For this the foundation was laid by the circumstances of his early life.

Grandson of Madison Whiteside, a pioneer manufacturer and leading business man in the State of Indiana, Walter H. Whiteside began life as a member of one of the wealthiest families in the State. The panic of 1873, however, swept away everything, and he was thrown on his own resources, his education being limited to a common school training and one year in a normal school. He began an apprenticeship course when less than seventeen years old in the machine shops of the Wabash Railroad, at Wabash, Ind., his birthplace. At twenty he began his commercial experience by introducing throughout Indiana and Michigan the Hercules dynamite and other explosives made by the Dupont Powder Company, for use in railroad, mine, and quarry work. The dangers with which this work brought him into contact developed in him a spirit of fearlessness often apparent in later years.

One incident of this period in his life shows his quickness in perceiving a good opening and availing himself of it. He originated the idea of making use of explosives for clearing away stumps on ground which was being prepared for agricultural use. In order to show the practicability of this idea, he undertook personally a number of contracts for clearing ground, and demonstrated his point so successfully as to largely increase his sales from this source alone.

His executive work began in 1885, and he held positions successively with the Cleveland Electrical Company, the Gates Iron Works, and the Westinghouse Electric & Manufacturing Company. It was while he was connected with this last-named organization that he did some of his best work. As district manager at Washington, D. C., he had much to do with installing electricity in the dry docks of the Navy Department, and with various other large enterprises. On his recommendation, the Westinghouse Company created a

new department, that of "details and supplies," at the head of which he was placed, and in a short time it became one of the largest and most profitable of their departments.

Since his joining the Allis-Chalmers Company, in July, 1904, his abilities have been shown by the many difficult tasks which he has satisfactorily accomplished—a better statement than could be made in any words to those who have had the opportunity of observing his work. Among these tasks were the consolidation of the old and the new interests, and the enlarging and entire reorganization of the sales department, both undertakings which might well have discouraged a less determined man. However, his election to the presidency offers a very good opportunity for making public, for the benefit of those who do not know him so well as do his business associates, the qualities which have brought him such success.

Mr. Whiteside is a man who makes himself felt, not merely as manager of one company or vice-president of another, but as a personality. The man dominates the office. He possesses an individuality and a force of character which stand out in any position which he may hold. The key-note of his personality is strength. His enthusiasm and energy are his most striking characteristics, and he possesses to a high degree the power of communicating these qualities to those with whom he comes in contact. He is a natural leader. His personal magnetism imparts to the organization of which he is the head a unity of feeling, which is a most valuable factor in any large concern, having many interests of widely different kinds.

His justice makes all dealings with him pleasant; all who are connected with him in any way recognize his fairness. He is entirely impartial, and in his relations with his men he sinks personality completely, judging a man from the standpoint of his work and the results obtained. This does not mean, however, that he considers his employees to be in any way machines; on the contrary, he expects them to think and to originate, and is always open to suggestions from them.

His capacity for work is the natural result of his vigorous temperament. The long hours which he expects those in his employ to keep, he also keeps himself; his working day seldom ends before that of the men in the shops. This constant personal attention is a great factor in his success; nothing which he ought to do is left to others.

Mr. Whiteside has a large circle of business friends and associates whose regard has been won for him by the same qualities which have brought him good fortune in business.

But in spite of all the prominence which he has attained, he is a modest man, as are most men who have really accomplished something that is worth while. What Mr. Whiteside has done in the past, the increase in the business of the company, the crowded shops, the reopening of the old South Foundry at Milwaukee, have already shown. What he will do in the future remains to be be seen, but may be prophesied from his former policy of expansion and organization. All that he has heretofore done has tended toward the raising of standards, the simplification of business methods, and the improvement of product. This policy is sure to lead to progress, when at the head of affairs there is a progressive, energetic, clear-sighted man, a man who can see the best course to pursue and who can act with decision and good judgment—and such a man is Walter H. Whiteside.

PHOTO BY KUEBLER, PHILADELPHIA

FREDERICK WINSLOW TAYLOR

THE NEW PRESIDENT OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

SEE PAGE 172

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CASSIER'S MAGAZINE

VOL. XXIX DECEMBER, 1905 No. 2

A NEW TYPE OF OCEAN STEAMSHIP

THE HAMBURG-AMERICAN LINER "AMERIKA"

By Julius Paul Meyer

THE MANICURE'S CORNER IN THE BARBER SHOP

AT the time when the keel for the "Amerika" was being laid at the yards of Harland & Wolff, at Belfast, in Ireland, a little over two years ago, several large new steamers of different trans-Atlantic lines were attracting much attention in steamship and engineering circles, owing to their speed, their size, or special features introduced in their equipment. In connection with one of them the statement was repeatedly made that in point of size and equipment, not to mention speed, the limit had been reached.

Since that time, however, the best men that could be found by the Hamburg-American Line,—men of their own staff as well as marine engineers, marine architects, hotel men, designers, and decorators,—were diligently at work frequently crossing on several of the most recently-built ocean steamers, studying all the later improvements introduced by them, with the one purpose in mind, to produce in the new ship "Amerika," then in course of construction, something that should be far in advance of anything afloat. The result achieved has been a revelation to the most experienced of ocean travelers. In fact, as one of the speakers at a recent banquet on the "Amerika" remarked, he had spent more than an hour inspecting the many new features contained in the great ship, and that, barring a bridle path for the equestrian, a smooth road for the automobilist, and a forest for lovers to walk in,

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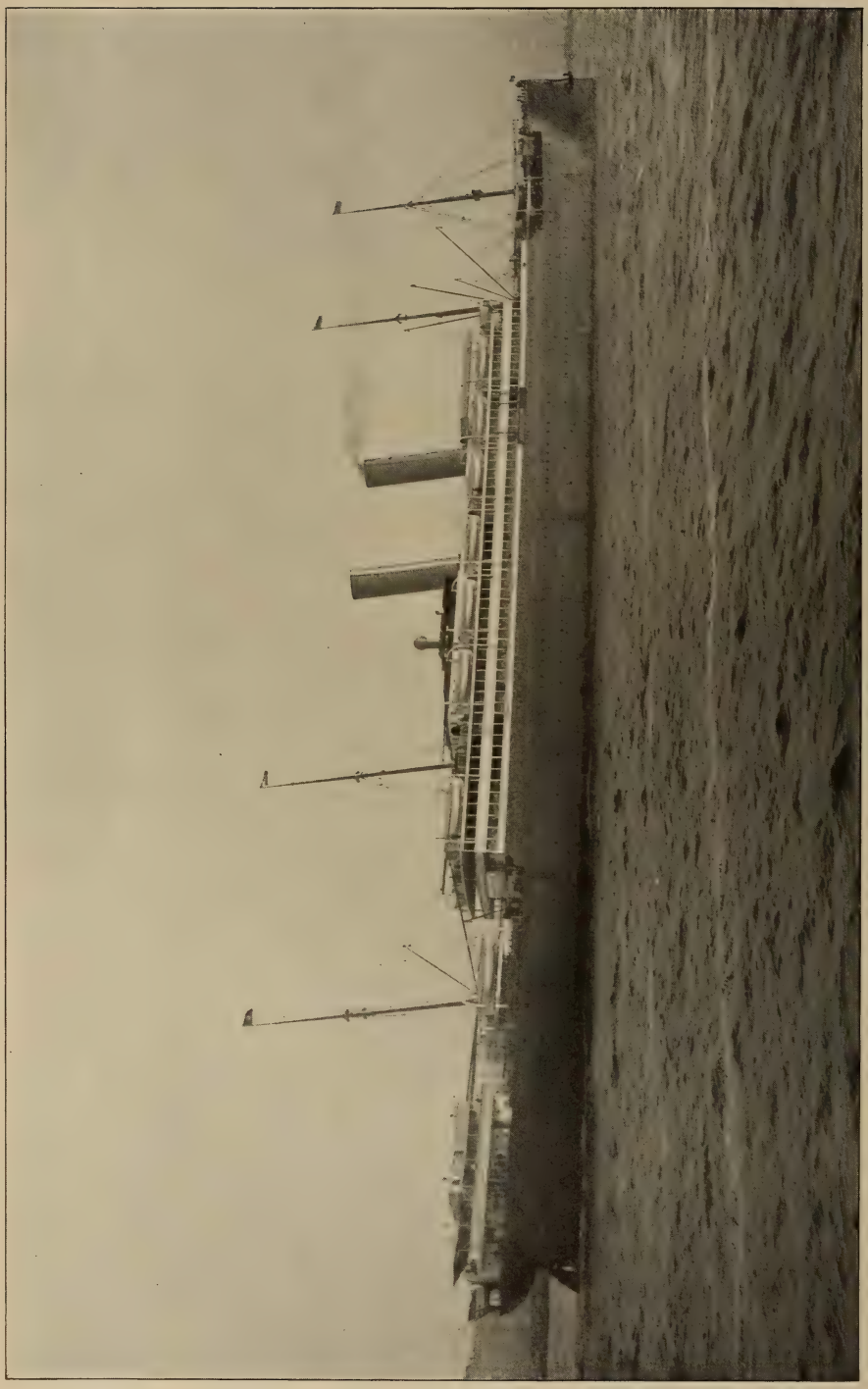


THE "AMERIKA," BUILT BY MESSRS. HARLAND & WOLFF, OF BELFAST, IRELAND, LEAVING NEW YORK ON HER FIRST EAST-BOUND TRIP. SHE IS 687 FEET LONG, WITH A BEAM OF 74½ FEET, AND HAS A DISPLACEMENT OF 42,000 TONS, MAKING HER THE LARGEST SHIP EVER BUILT. HER TWIN SCREW ENGINES DEVELOP 16,000 I. H. P. SPEED 18 KNOTS

THE BARBER SHOP IS MOST LUXURIOUSLY EQUIPPED

everything else seemed to have been provided.

The "Amerika" was launched at Belfast on April 20, 1905, and her first voyage across the Atlantic was made last October. She is 687 feet long, with a beam of 74 feet 6 inches, and a depth of hold of 53 feet. Her displacement at full-load draught is over 42,000 tons,—a greater displacement that that of any other ship in the world. Her full cargo capacity, however, cannot be utilized until the new channel now being dredged at the entrance of New York Harbour is completed, as her draught at full load will be approximately 36 feet; the present depth of the channel will not permit the entry of vessels drawing more than 32 feet of water.

To further illustrate the enormous size of the "Amerika," it may be mentioned that she has accommodations for 4000 persons, including a crew of 600 officers and men, and will be able to carry 500 first-class passengers, 300 second-cabin passengers, 300 third-cabin or "intermediate" passengers, and 2300 persons in the steerage. The "intermediate" class is something entirely new, and was introduced to meet a demand for an accommodation not as expensive as second cabin, but better than steerage. The third cabin is equipped with rooms for two, four, and six persons, and has a large dining-room.

The four principal decks of the ship are surmounted by a superstructure 400 feet in length, containing three large promenade decks, so that in all seven decks are available for passenger accommodations. The decks have been specially named as follows:—Beginning at the top, boat or sun deck; "Kaiser" deck (upper promenade deck); "Washington" deck (lower promenade deck); "Roosevelt" deck (upper deck); "Cleveland" deck (saloon deck);

A GLIMPSE OF THE UPPER PROMENADE DECK

"Franklin" deck (main deck); and lower deck. Names have been chosen for most of them to facilitate matters for the passengers in locating their staterooms.

For the safety of the ship the hull is provided with a double bottom as a safeguard in case of grounding. Above this double bottom there are water-tight steel bulkheads, extending to the upper deck, and the engine compartment, which is the largest in the ship, is divided by a longitudinal bulkhead. These water-tight compartments make the ship practically unsinkable. All the bulkhead doors can be closed in a few seconds either individually or collectively from the captain's bridge, and the mere entrance of water into any one or several of the compartments would automatically close the bulkhead doors in the compartments affected in the event of any defect in the connection with the bridge. The power needed to operate the system is quite independent of the ship's engines, being derived from hydraulic pressure from accumulators.

The "Amerika's" engines are quadruple expansion, in two sets, each set driving a four-blade bronze propeller, 21½ feet in diameter and 24½ feet pitch. The combined indicated horse-power is about 16,000, giving the ship a speed of about 18 knots.

There are five electric generators in the engine room, each of about 100-KW. capacity, and one of the same size on the upper deck, so that in the event of the engine room being flooded, the upper parts of the ship can still be lighted. Thirty-two hundred 25-candle-power incandescent lights are in service, making the "Amerika's" electric lighting equipment the largest ever installed aboard ship. Two refrigerating machines are provided for the perishable cargo and provisions. There are also two evaporators for fresh water service for all purposes. The ship needs about 1000 tons of fresh water for the trip each way.

There are two main boiler rooms, each containing four boilers. Each boiler has six furnaces, so that in all there are forty-eight furnaces. The steam pressure carried is 215 pounds. The Howden system of forced draught is employed. The consumption of coal is about 260 tons per day. The ashes are removed by four ash ejectors. For the ventilation of the gangways, especially the cabin gangways, the spaces between the funnels and the funnel casings have been made to serve as excellent exhausters. For the ventilation of other parts of the ship, as previously intimated, ventilating fans are used. There are no ventilators on deck.

The principal problem of design in the new ship was in connection with the passenger departments. The great advances which had been made in every direction in recent years in the equipment of passenger steamers had to be surpassed, and how well this was accomplished is most strikingly illustrated here. To obtain the best results in the arrangement and furnishing of the various public rooms and staterooms, the contracts were given to the following well-known firms:—J. D. Heyman, of Hamburg; Waring & Gillow, of London, and Paul Sormani and P. H. Remon, of Paris. Thus the best brains and skill of Germany, England, and France, were brought into competition with the result that a degree of comfort, beauty, and effect was secured hitherto undreamt of on an ocean liner.

The most distinctive feature which will distinguish the "Amerika" from all other passenger steamers afloat, is that for the first time in the history of ocean travel there will be found on board a restaurant à la carte in addition to the regular table d'hote dining-room. The idea originated with Mr. Albert Ballin, director general of the Hamburg-American Line, who had several years before introduced grill rooms on several of the best ships of the company. These were so much appreciated by the traveling public that it was de-

AN ELECTRIC PASSENGER ELEVATOR IS ONE OF THE FEATURES OF THE SHIP'S EQUIPMENT, THE FIRST ONE TO BE SO INSTALLED

cided to extend this popular feature and establish on the new steamers "Amerika" and "Kaiserin Auguste Victoria," the latter not yet completed, a restaurant à la carte equal to the best restaurants of Paris, London, Berlin, and New York.

To secure the very best advice in this respect, Mr. Ballin took the matter up with the directors of the Carlton Hotel in London, who own and operate, under the general management of Mr. Ritz, the most famous hotels in Europe, with the view of obtaining their co-operation in carrying out his idea. Although the first mention of establishing restaurants à la carte on ocean liners startled them somewhat, it was decided ultimately that Mr. Ballin's

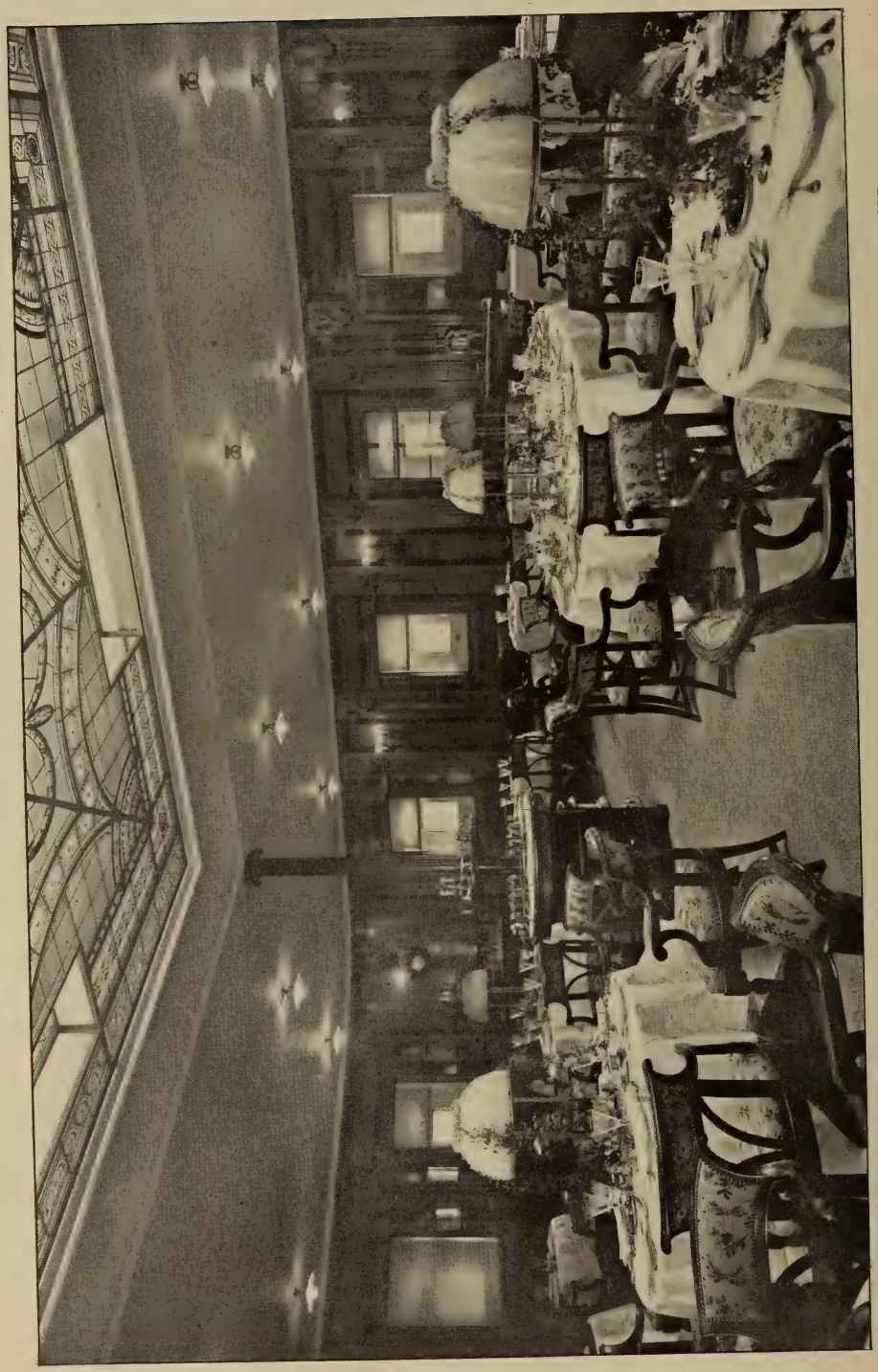
idea was not only practicable, but that it contained the elements of brilliant success. For more than a year Mr. Ritz and his associates, particularly Wm. Harris, one of the directors of the Carlton Hotel, in London, devoted much of their time to the carrying out of the plans adopted, and they are all convinced that the Ritz-Carlton restaurant now in operation on the "Amerika" will be a credit to the name it bears.

The restaurant will seat about 120 people at a time, and is placed in an excellent position amidships on the promenade deck. It has a separate kitchen, separate service, and separate provision stores. The meat, fish, poultry, vegetables, and all other provisions will be of the quality used in restaurants of the highest class. A welcome change will thus be afforded to those passengers, and they are many, who prefer, however good a table d'hote may be, to order their own meals à la carte, and eat them at their own time, at separate tables, with their relatives and friends. Passengers will have the option of taking transportation tickets only, paying separately for their meals.

When buying their passage tickets without meals, passengers receive varying rebates, according to the value of their accommodations, and those who prefer to take their passage including all meals, but who wish to dine occasionally in the restaurant à la carte, will be entitled to certain rebates for each meal whenever such meals are taken in the restaurant, provided that notice has been given to the chief steward not later than the evening before the luncheon, and up to 11:30 a. m. for dinner.

These rebates will be deducted from the bill which is rendered for the meal taken in the restaurant. On the re-

A CORNER IN THE NURSERY



A VIEW OF THE RITZ-CARLTON RESTAURANT ON THE "AMERIKA," ONE OF THE HIGHEST TYPES OF OCEAN COMFORT

cently completed first westward voyage of the "Amerika" the demand for seats in the restaurant was frequently so great that there was a waiting list, and on her first return voyage from New York nearly fifty per cent. of the passengers patronized it daily. This speaks well for the popularity of this new feature in the company's service.

In providing for the open-air recreations of the vessel's passengers, the builders have had a comparatively easy task, her huge dimensions lending themselves readily to the arrangement of a number of fine promenade spaces. There are, as previously mentioned, seven decks. The opportunities thus furnished have certainly been turned to good account. First-class passengers, for instance, will have no less than three decks on which they can promenade, *i. e.*, the boat deck, and the upper and lower promenade decks; while cozy bowers situated at the extremities of the deckhouses will enable the lazy ones to enjoy the *dolce far niente* secure from the buffetings of rude Boreas.

The lower promenade deck, it may be added, will be for promenading in the true sense of the word. The deck-chair lounger will have to betake himself to the decks above, no such obstructions as chairs being allowed in this quarter. We all of us know how the morning constitutional or the after-dinner stroll aboard ship is usually marred by a series of stumbles over the outstretched legs of some less energetic one, and, accordingly, a deck which is reserved strictly for pedestrians will be a huge advantage.

Before entering upon any detailed description of the interior arrangements of the ship, it may be of interest to point out some of the features which are distinctively the "Amerika's" own. To begin with, there is an electric passenger elevator which was used by no less than 5200 persons on the first voyage across the Atlantic, making in all 1825 round trips. The elevator was installed by Messrs. R. Waygood & Co., of London. The "Amerika" is the first vessel equipped with a passenger elevator, and to the Hamburg-American Line belongs the credit of first adopting an idea which promises to be of the greatest convenience, especially for ladies and invalids. Another important feature is found in the system of ventilation, which extends to every cabin and saloon of the ship. To prevent draughts in the companionways, usually cold and uncomfortable on stormy days, wind screens have been placed within the doorways leading on deck which make it impossible for a draught to be felt.

In addition to the ordinary sea-water baths, for which there are in all fifty bathrooms in this ship, there is an electric-light bath and massage room in charge of specially trained attendants. For the ladies a hairdresser's shop has been installed, containing every necessary appliance of the most up-to-date establishment of its kind. Another novelty is a florist's shop, located on one side of the great companionway, where fresh flowers may be obtained during the entire voyage. A specially equipped refrigerator has been installed in which fresh flowers can be stored during the entire voyage, both for sale to the passengers and for floral decorations for the tables in the restaurant during the trip. And what an opportunity the florist shop will afford to those desiring to extend a compliment for any occasion during the crossing!

Other special features are a nursery for children; trained nurses for the sick, attached to the doctor's staff; a specially equipped gymnasium with all the latest appliances of the Zander system for exercise and muscle building of the same kind as the one originally introduced by the company on some of their other ships; an extensive and carefully selected library of standard works in German, English, and French; lower

THE SMOKING ROOM IS IN SOLID OAK, OF ROUGHLY FASHIONED SIXTEENTH CENTURY TYPE

berths only in most of the cabins; and finally a special fire extinguishing system, which, by forcing sulphuric acid gas into the compartment in which a fire may happen to break out, will promptly smother the flames.

As a matter of course the Marconi wireless telegraph system has also been installed, and arrangements are now being made with the Marconi Company for their long-distance messages, as it is intended to publish a daily paper on board, containing the latest news of what is going on in all parts of the world.

For the convenience of passengers an information bureau, in charge of a competent clerk, has been introduced, where railroad tickets and much information about train and steamer connections may be obtained.

To have entrusted the work of decorating and furnishing to one of the leading firms in Germany, and to another one in Great Britain, as well as to the eminent firm who are building the ship, and to two prominent establishments in France, might by

some other company have been deemed sufficient, but by the Hamburg-American Line still more was done to insure complete satisfaction. They arrived at a conclusion which, when stated, seems very obvious, but which, thus far, had not occurred to any other shipbuilder, and that is, that the navigation of a ship and the housing and catering arrangements for its passengers are two totally different things, and that the second

ONE OF THE PRIVATE BATH ROOMS

should be planned by and entrusted to trained hoteliers and restaurateurs, just as the former is entrusted to skilled mariners. Acting on the conclusion so arrived at, the plans and designs for the decoration, furniture, and equipment of the principal rooms were prepared by Mewes & Davis, the architects to the Carlton Hotel, London, and its offspring the Ritz Hotel, in Piccadilly, London, and to the Hotel Ritz, in Paris. The ship, in short, so far as the catering and creature comforts of the passengers are concerned, has been regarded as what it really is, a floating hotel, and it has received the advantage, for the first time in shipping enterprise, of the expert knowledge of men accustomed to design the decoration, furniture and equipment for hotels and restaurants of the highest class. Thus, to German capacity for organization and thorough-

THE GYMNASIUM IS FITTED UP WITH ALL THE LATEST ELECTRICALLY OPERATED APPLIANCES OF THE ZANDER SYSTEM

ness of detail has been added the practical good sense of Britain, the ingenuity of the United States, and the genius of France.

The dining-room is of imposing size, nearly 100 feet long and extending the whole width of the ship. In the decoration and furnishing of this room an adaptation of the style of Louis XVI. was decided upon. The colour scheme is charming. The walls are pearl-gray. The chairs and buffets are upholstered in gold-coloured West Indian satin with green veins, thus matching the yellow gold shades of the table covers and carpets.

In front of the dome-like central elevation a bas-relief of George Washington, modelled by an American artist, is the leading feature.

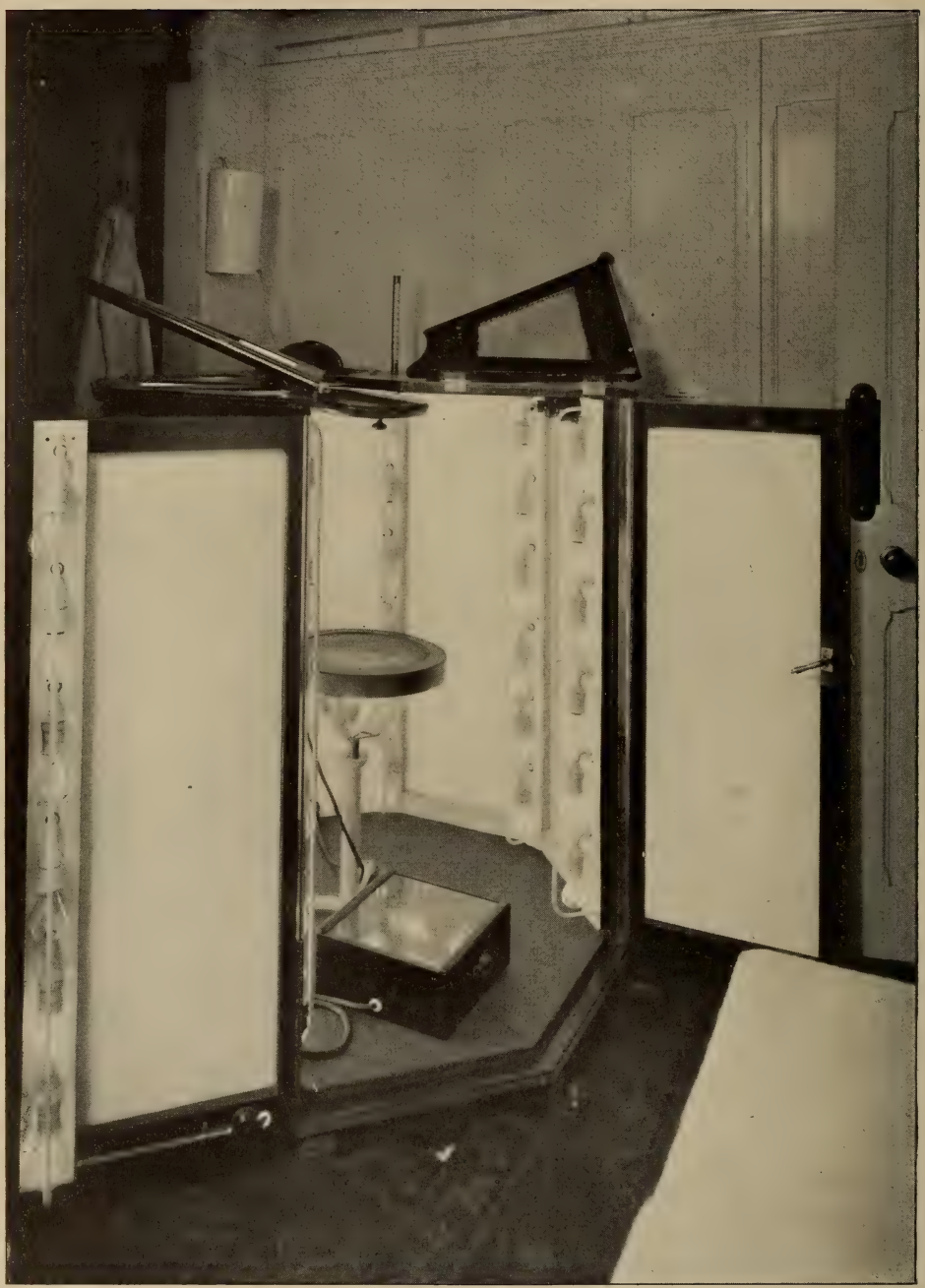
Much care has been taken with the lighting. The electroliers, in mercury-gilt bronze, are of beautiful design, while the center tables are lighted by electric table lamps. Bronze garlands of mercury-gilt, suspended from the balusters, as well as from the clock of the dome, further enhance the lighting arrangements.

In the ladies' drawing room white is the predominant colour. A beautiful relief has been obtained on the walls by the use of jasper blue Wedgwood plaques in connection with the electric light fittings. A fine white marble chimneypiece, with its delicate carving, is a striking feature of the room. The general treatment is simple, but the effect is most pleasing. The pale rose-coloured silk of the upholstery, and the finely embroidered curtains of rose and silver help to soften the effect of the white walls, the whole being harmoniously completed by a carpet in shades of pearl-gray. The room is furnished with fine satinwood commodes with decorative panels, copied from Angelica Kauffmann's best work, and carrying book cases spacious enough to hold an extensive library.

A writing room adjoining the drawing room is treated in a boudoir type of the Empire style, the white panelling being relieved with tasteful gilt ornament and with heliotrope-coloured silk in panels. The furniture consists of reproductions of old Empire models, with finely-shaped gilt and bronze mounts of the period. The room is lighted with chased and gilt reproductions of Empire plaques, and is throughout thoroughly characteristic of the style.

In contrast to the writing room, the smoking room was carried out in solid oak, of the roughly-fashioned type of sixteenth-century work, after the style of the great hall or hunting room in an Elizabethan manor house, all the panelling being hand made, and left with the characteristic rough tool marks. The room consists of two floors connected by a fine staircase. Around the upper floor is a beautiful carved frieze in light wood, left in its natural state, forming a vivid contrast to the oak. The carving itself is most interesting, being carried out in the style of the period with a bold finish full of vigour and artistic feeling. It is illustrative of hunting and incidents in the life of St. Hubert, the patron saint of huntsmen. Other artistic contrasts to the oak are obtained in a fine brickwork chimney piece and stone hearth.

If there is one class of passengers which requires more attention than any other, it is the children, and in connection with these also thoughtfulness was displayed. The ship has a special room equipped as a nursery. The walls of this room are white, and are appropriately decorated with paintings illustrating "Little Red Riding Hood," "Grimm's Tales," "Struwelpeter," and the other nursery lore of the different nations which may be expected to use the vessel. The seating, provided in various heights suitable for children, is covered with rough blue canvas with applique of Russian embroidery in red and black. In the construction of the furniture great care has been taken to avoid all sharp corners; the upholstery will be particularly thick,



AN ELECTRIC LIGHT BATH ACCESSORY TO THE GENERAL BATH ROOM EQUIPMENT

and in every other way the room has been made practical and safe as well as cheerful.

The principal state rooms and cabins are all panelled, mostly painted in white, and are charmingly furnished, each room having a distinctive character and style. Nor is the artistic effect everything; the chairs, settees, and the furniture generally, have been most carefully considered by the architects and designers from the point of view of comfort, a very important factor with the passenger who is crossing the Atlantic; and luxurious ease, as well as charm of design and fidelity of style, have been secured.

The principal styles adopted in the cabins and private sitting rooms are Queen Anne, with oak furniture inlaid with walnut; Georgian, with walnut inlaid with boxwood; Adams, with inlaid satinwood; and Sheraton, with inlaid mahogany. One very charming suite of rooms has been decorated in the Louis XVI. style, with furniture painted light green, and another has mahogany furniture in the Empire style.

There are twenty self-contained suites on board, some consisting of bedroom, private sitting room, and private bathroom, and others giving even greater accommodation.

In all the cabins with the exception of those on the lowest deck the much-disliked upper berth is abolished, and the beds are furnished with a new invention by which both passenger and beds are kept perfectly secure even during the roughest weather. Instead of the small washstand generally found in the cabins of passenger steamers, a commodious open basin with a direct water connection has been provided in all cabins *de luxe*.

Every detail of the furniture and equipment has been carefully studied and it may be safely said that there are few hotels in London, Berlin, Paris or New York, in which the bedrooms and sitting rooms, having regard to the space available, can well bear comparison with the rooms to be here found. Telephones have been installed in all of the larger apartments.

Though so much attention has been paid to the accommodation and comfort of first-class passengers, the comforts of the second class have been equally regarded and as carefully and adequately thought out. The second-class passengers will find that the accommodation on the "Amerika" is of a superior type to that found on any other Atlantic liner.

The dining saloon is on the main deck, and occupies the full breadth of the ship. The walls are finished in enamelled white panelling, lined with colour and set off with sea-green carved medallions. The ceiling is white, with gilt and sea-green decorations in bas-relief. The upholstery is green, and the floor, oak parqueterie laid with green and copper-red carpet runners.

The second-class drawing room, like the dining-saloon, is enamelled white, with carved medallions and engravings after Gainsborough, mirrors adorn the walls, and the ceiling is richly panelled and moulded. A delicate shade of slate blue has been chosen for the curtains and upholstering.

The second-class smoking room is at the after end of the vessel, on the same deck as the drawing room. Dark red pegamoid was used for the upholstery, and copper-red for the floor; the panelling is in smoked oak, and two handsome pictures complete the decoration.

The staterooms are in the after part of the ship on the upper and main decks,—principally on the former. The rooms are spacious, well ventilated, well furnished and just as comfortable, if not so exceedingly luxurious, as those of the first class; in fact one might easily imagine himself in the first-class portion of the ship. The furniture is of polished mahogany, including the folding lavatories, which are of par-

THE MUSIC ROOM

THE "WASHINGTON" DECK COMPANION WAY. THE FLOWER SHOP CAN BE SEEN IN THE BACKGROUND

THE KITCHEN IS MOST ELABORATE IN ITS APPOINTMENTS

ticularly handsome design. The bulkheads and ceiling are finished in enamel white. A rich moquette has been chosen for the upholstery; the carpets match the sofas and the curtains. An unusual feature in second-class accommodation is that electric sockets have been provided in the staterooms so that passengers may enjoy the convenience of stateroom fans or portable lamps, while the ladies may have their curling irons electrically heated.

The kitchen and pantries, store-rooms and refrigerators,—in fact every department connected with the catering,—have been planned with the greatest care, and more space has been allowed to this department on the "Amerika" than will be found on any other large passenger vessel. This was done upon the advice of the hotel experts, as they considered more space a necessity to give superior service for the ship's main dining-room.

In connection with this most interesting part of a great steamer, some figures of the supplies necessary for a voyage may prove interesting, and will also give some idea of the immensity of the company's commissary department, which has to provide for a fleet of 350 vessels, of which 150 are large trans-Atlantic steamers. The figures are for a combined passenger and crew list of 4000 persons on a $7\frac{1}{2}$ days' trip.

Figuring on this basis there are required of fresh provisions for a single trip, one way, 32,000 pounds of beef, mutton, lamb, veal, and pork; 7500 pounds of game and poultry; 3500 pounds fresh, and 250 pounds smoked fish; 7500 pounds assorted fruit; 80 cases of oranges; 36,000 eggs; 12,000 pounds fresh bread, and about $450 worth of fresh

vegetables. For the outward and return trip there would also be required 9000 pounds canned meats; 3600 pounds of salted meat; 4850 pounds ham, sausages, smoked meat and tongue; 1800 pounds bacon, 5000 pounds butter; 4500 pounds cooking butter; 3600 pounds cheese; 50,000 pounds flour; 15,000 pounds rice, etc.; 4000 cans vegetables; 4100 pounds coffee; 300 pounds tea; 3500 pounds sugar; 8000 quarts milk and cream; 4000 pounds sauerkraut, and 20 tons herrings. There would be required to quench the thirst, 15,000 quarts of beer in kegs, and 1200 bottles of beer; 960 quart and 1300 pint bottles of champagne; 1260 quart and 900 pint bottles of Bordeaux and Burgundy wines; 1680 quart and 1400 pint bottles of Rhine, Moselle and Saar wines; 3500 quart and 6000 pint bottles mineral waters, and 950 bottles of liquors and spirits.

The "Kaiserin Auguste Victoria," now nearing completion at the yards of the Vulcan Shipbuilding Works, at Stettin, Germany, will be ready for service in the spring of 1906. This vessel, while in a general way of the same type as the "Amerika," will have even greater dimensions, making her the largest ship afloat. The "Kaiserin Auguste Victoria" will be 700 feet long, 77 feet wide and 54 feet deep, with a gross tonnage of 25,000 tons and a displacement of about 43,000 tons. In her general appearance and interior arrangements she will be about the same as the "Amerika."

While great credit is due to the builders, Messrs. Harland & Wolff, of Belfast, and to the many designers and decorators for what they have accomplished, the greatest credit for this new marine creation belongs to the Hamburg-American Company's Director-General, Mr. Albert Ballin, whose genius, energy, and foresight have brought the line to its present high place among merchant marines.

The photographs reproduced in the preceding pages were taken by Byron, of New York City.

INDUSTRIAL SMOKE AND ITS PREVENTION

By John B. C. Kershaw, F. I. C.

ALTHOUGH it is now nearly sixty-years since Charles Wye Williams first published in Liverpool a small book entitled "The Combustion of Coal," and taught that smoke was the sign of imperfect or wrong conditions of combustion and, therefore, largely preventable, the smoke problem to-day is of much greater extent and calls even more urgently for a remedy than when Williams wrote and published his first book on this subject.

It is, in fact, remarkable that this book should have produced so little effect, for it contains the fundamental principles of combustion, though expressed, it may be admitted, in language and by chemical symbols and formulæ which would hardly pass current to-day. Nevertheless, the book is worth reading, either in its original form, or in one of the reprints (published in 1854 and 1886 respectively) for the sound practical teaching it contains regarding the conditions necessary for attaining perfect combustion of coal in boiler furnaces.

The theory of the chemistry of combustion has varied at different dates, and that which holds the field to-day is not that of ten years ago, while that of ten years ago was again not that of Williams' day. But the practical connection between the maintenance of proper conditions of combustion and absence of smoke does not vary, and on the practical side, Williams' teaching is as applicable to the conditions of to-day as it was to those of his own time.

The following extracts from the book will show that this appreciation of Williams' work is not without justification, and that he may rightly be regarded as the pioneer worker in all attempts to minimize the smoke nuisance and to obtain more perfect combustion of coal when used for heating purposes:—

"It may be asked how it has happened that hitherto this (the smokeless combustion of fuel) has not been effected? I answer because the chemistry of combustion has been neglected, not in the laboratory, but in practice; and because the construction of our furnaces has been too much left to those who know little of the chemical properties of the materials which are consumed in them. * * *

"A charge of fresh coal thrown on a furnace already in an active state, so far from augmenting the general temperature, or giving out heat, becomes at once an absorbent of it. * * *

"I have proved during the last fifteen years, that even in the largest establishments, and in the furnaces of steam boilers the great nuisance of smoke may be avoided, and even with the accompaniment of considerable economy. * * *

"In marine and cylindrical land-boilers the combustion chamber is invariably made too shallow and too restricted."

Williams clearly pointed out that the combustion of bituminous fuel involved two distinct things,—namely, the liberation and combustion of the volatile gases in a suit-

able chamber, and the combustion of the solid coke in the bars of the grate. In one place he described how he proposed to put into practice these principles of fuel combustion, and showed drawings of boiler furnaces with properly designed and scientific arrangements for providing a secondary and heated air-supply behind the bridge. He was very sarcastic at the expense of inventors who, even in his day, were patenting devices for "consuming smoke," instead of attempting to show how to prevent its original formation.

The above extracts prove that this was altogether a remarkable book to have been written and published nearly sixty-six years ago. Many of the so-called patents of the present day are, in fact, simply unconscious adaptations of Williams' ideas, and are therefore invalid,—while most of the suggestions for reducing the industrial smoke evil made by modern writers are similarly based on those made by Williams in the book to which attention has just been drawn. But although this apparent appropriation of another man's ideas without acknowledgment is not an edifying spectacle, it has some advantages, since it helps to keep his teaching before the public mind.

In the following pages the writer proposes to refer to some of the earlier and later papers and publications on the subject of smoke prevention, to trace the connection between these and Williams' earlier work,—and finally to make some practical suggestions for inaugurating a more active and educational propaganda concerning the scientific principles of fuel combustion among manufacturers and others using coal for steam raising or other heating purposes.

The writer is convinced that in time the dictum of Williams that "smoke is preventable," will be generally accepted, and that it will also be found that smoke-prevention is allied with fuel economy. But much educational work will be required before this end is attained and before manufacturers have realized that a comparatively smokeless chimney need not necessarily mean a higher consumption of fuel. A practical illustration of one method by which this educational work is being carried out on the Continent of Europe is given under the account of the work of the Hamburg Smoke Prevention Society, and it is to this account that the attention of readers of this article is especially directed. There is no reason why similar societies should not be started in every large industrial center in every country, and it is only by work along some such lines that real progress in fighting the smoke nuisance will be made.

THE WIGAN COAL TRIALS OF THE MANCHESTER ASSOCIATION FOR THE PREVENTION OF STEAM BOILER EXPLOSIONS

In the years 1867-1868, this association, now known as the Manchester Steam Users' Association, carried out a series of steam-raising trials with South Lancashire coals at Wigan, in order to prove to the Admiralty authorities that this class of coal could be burned with high efficiency and without smoke, in the furnaces of both land and marine boilers. The results of these tests were published in the monthly reports to members of the association for July and September, 1868, by L. E. Fletcher, chief engineer of the association, and these form most instructive reading at the present time when the burning of bituminous fuel without smoke in the furnaces of steam boilers is still considered an unsolved problem.

In these Wigan trials evaporative efficiencies of from 9¼ pounds to 10 pounds of water per pound of coal* were obtained without smoke emission by careful attention to the details of firing and draft regulation. Mr. Fletcher, in fact, states in his summary, that the trials "fairly establish the conclusion that the smoke

* No feed-water heater was employed.

nuisance admits in all cases of considerable abatement, and in most of total removal."

The methods of attaining comparatively smokeless combustion with high efficiency from bituminous fuel, in these trials were practically those recommended by Williams twenty-seven years earlier, and the chief novelty of Mr. Fletcher's reports is the insistence upon the fact that a good stoker is a sine qua non, if these methods are to be carried out in practice. His remarks on the position of the stoker are indeed noteworthy, and are here reproduced:—

"I cannot conclude these remarks without calling attention to the great influence of careful stoking simply on smoke prevention. These trials have proved how very much depends on the proper use of the shovel. The stoker who has fired the boilers throughout this series of experiments, as well as the previous one with the Admiralty boiler, takes an interest in his work, and considers stoking as his profession. In this way I think it should be viewed. Firing is an art, and should be treated as such, and not as a slap-dash random process which any untaught labourer can accomplish. To a great extent our smoke producers are stokers. Educate the stokers in their art, and smoke will be prevented. They should be instructed in the first instance how to fire without producing smoke, and be stimulated to constant care by a fine on failure, and a premium on success. If steam users were united in the movement, the question would soon be settled."

Had this advice been followed up vigourously by all manufacturers during the thirty-five years that have elapsed since these reports were published, the smoke problem would today be largely non-existent, for stokers would have been elevated into a class of skilled labourers, and would have learned how to carry out their difficult work without plastering the skies and buildings of large cities with smoke and soot.

DISCUSSION ON SMOKE, BEFORE THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

In December, 1902, the American Society of Mechanical Engineers devoted one of their evenings for topical discussions and notes of experience to the question of Smoke.

G. C. Henning referred to the Central Electric Station in Vienna, which is placed exactly opposite the Archduke's Palace, and is compelled to carry on its operations without any smoke emission from its chimneys. The coal burned at this station is of a very poor quality, and, under ordinary conditions of firing, would produce much smoke. By an automatic arrangement of air supply, known as the Langer system, which admits air and steam to the combustion chamber of the boiler furnaces for a few minutes after firing, this coal is burned without a trace of smoke. This automatic apparatus was stated to be in use also at the City Hall and at the Opera House and Court Theatre in Vienna. Very frequent firing was stated to be in use with this system of smoke prevention, and the principle of "little and often" was practically carried out.

Here we have an example of a successful attempt to minimize the smoke nuisance in a large city. The Langer apparatus would appear to be merely a modification of Williams' bridge air-supply, worked automatically by means of a steam jet and controlled by the movement of the furnace doors. It is, in fact, probable that had the engineers of the Central Electric Works at Vienna been well grounded in the teaching of Williams' book, they would have been able to attain perfect combustion of their fuel without smoke, by simple attention to the principles laid down by that author. In any case, the method of firing "little and often" greatly assists in minimizing smoke, and it is to this feature of the firing that the success of those in charge of the boiler installation named above is partly due.

THE SMOKE PROBLEM DISCUSSED BEFORE THE INSTITUTION OF ENGINEERS AND SHIPBUILDERS OF SCOTLAND

On October 25, 1904, a paper on this subject was read by F. G. Rowan before the society just named, and in the following month a lengthy discussion upon it took place. The author dealt with the subject under four heads, and under the first of these,—smoke production,—referred specially to the work and writings of C. Wye Williams. On the subject of smoke prevention the author stated that most of the past efforts to suppress smoke had started at the wrong end, and that what was wanted was not apparatus to burn smoke, but methods and apparatus to prevent its formation. This was possible at the present day, and was simply a question of using proper apparatus and methods of firing. As regards the future, he stated his belief that in time manufacturers would have become sufficiently educated and enlightened to take an interest in their furnace and boiler plants, and to take pride in the fact that these were being operated without smoke.

A large number of members joined in the discussion of this paper. G. Andrews stated that, in his opinion, the principles of combustion and of furnace design should be taught in the technical schools. A. Sproul gave details of a smoke-preventing apparatus in use in Glasgow, which had given excellent results. This apparatus depended upon the reutilization of the exit gases by aid of a steam jet, and with it an evaporative effect of 13 pounds of water per pound of fuel was said to have been obtained, with complete combustion of the hydrocarbon gases. This method of utilizing a portion of the wasted heat of the exit gases is indeed striking in its simplicity, but unless a very large excess of air is being used these exit gases cannot supply much oxygen for the combustion process, and they must simply serve to raise the temperature of the cold air drawn in with them. To draw into the furnace a large excess of air, in order to reutilize only some portion of it, is a questionable method of promoting economy.

A similar process under the name of the Eldred process is, however, now being employed for heating furnaces, and very striking results are said to have been attained with it. Until further details and results of tests are available, however, the writer prefers to suspend judgment upon its application to boiler firing. The evaporative results quoted by Mr. Sproul, in fact, require independent corroboration before they can be accepted as of scientific value, for the evaporations named above represent a thermal efficiency of the boiler plant of over 90 per cent.

THE SMOKE QUESTION.—A PAPER READ BEFORE THE VEREIN DEUTSCHER INGENIEURE

Herr Haier, the author of this paper, until the spring of the present year, was chief engineer of the Hamburg Society for Promoting Boiler Efficiency and Smoke Abatement,—a voluntary society of manufacturers founded in 1902. Herr Haier based his remarks chiefly upon the experience gained and tests made, in connection with the work of the above society, during the first two completed years of its existence.

The first section of his paper is devoted to a consideration of the relationship that exists between the efficiency of the fuel used for the boiler fires and the amount of smoke produced. It is pointed out that a large excess of air reduces the amount of smoke produced, leading to large losses of heat in the waste gases, while at the other extreme but slight excess of air may be employed with almost equally large losses of heat, due to incomplete combustion and formation of carbonic oxide. Details of some practical trials, carried out in 1903 to illustrate the relation between these losses, are given, and a useful diagram presents the results in graphic form.

This shows that the percentage of heat of the original fuel utilized in the boiler varied from 54.4 up to 69.25 per cent., and that the latter efficiency was obtained with a moderate excess of air, equivalent to 13.4 per cent. CO_2 in the exit gases, and a moderate production of smoke. The lowest efficiency was obtained with the excess air reduced to a minimum, by use of a very slight draught and thick fires, and was accompanied by a heavy emission of smoke. Further trials are quoted to prove that when fuel containing 30 per cent. of volatile matter is employed for firing water-tube boilers, special forms of grate are required to obtain smokeless combustion with high efficiencies.

The author summarizes the results of all these experiments by stating that the thermal losses due to smoke production are less than is generally supposed, but that the losses due to excess air are much greater, and that it is by attention to the latter that engineers in charge of boiler plants will find their reward in an increased efficiency of the whole installation.

The two questions of smoke prevention and fuel efficiency are, however, closely connected. The author discusses methods of smoke prevention, and divides them as follows:—

(a) Use of special classes of fuel;

(b) Use of special methods of firing and automatic stokers;

(c) Use of specially trained men as firemen.

Under (b) he points out that with careful attention and scientific supervision, high efficiencies combined with little smoke production can be obtained with bituminous fuels, when hand-fired, with the ordinary type of furnace, in Lancashire boilers, and that the necessity for using patented appliances or automatic stokers under such conditions is largely imaginary. He gives details of special tests made in Hamburg, with hand-firing, but carefully watched and regulated, and shows that the thermal efficiency was increased in one case by 7 per cent., and in another by 14 per cent., by merely instructing the firemen in the principles of correct firing.

Under (c) he gives particulars of the society which has been formed in Hamburg for instructing and checking the firemen of industrial boiler plants. The need for scientific control is strongly insisted on.

The author deals finally with the practical results of the methods of control described immediately before and with domestic fires. As regards the former, he states that practical steam-raising trials are not sufficient to guide one in deciding upon the efficiency with which any boiler installation is operating, and that testing of the waste gas is absolutely essential to scientific control. The testing of the exit-gases is, in fact, for boiler work, what tests with the indicator are for steam-engine control.

The work of the Hamburg Society of Fuel-Users is certainly the most useful and practical of any that has come under the writer's notice, and it is interesting to note that the principles which are guiding its action are largely those urged by C. Wye Williams and L. E. Fletcher in Great Britain, in the years 1840 and 1868.

The scientific control of the combustion process and the use of men of adequate training and experience for the work of stoking, are the two fundamental principles for successful action in attacking the smoke nuisance, according to these two writers, and it is exactly along these lines that the Hamburg society is working. The training system for stokers which has been successfully introduced at Hamburg, might with advantage be copied in every large town and industrial center in Great Britain and in America, for it is precisely here that British and American manufacturers, even when anxious to effect improvement, find themselves hampered and checked. In Great Britain and America efficient and expert stokers are largely self-trained,

and the supply is deficient in the extreme. At Hamburg, thanks to the work of the society referred to, over 300 stokers have already been specially trained in their calling, the number is being added to each year, and no member of the association need trust to chance for obtaining the services of expert stokers when required for attendance to the furnaces of his boiler plant.

SMOKE ABATEMENT.—A PAPER READ BEFORE THE ROYAL INSTITUTE OF PUBLIC HEALTH AT LONDON

H. Adams, the author of this paper, contributed to the recently held Public Health Congress in London (July, 1905), dealt chiefly with the problem of domestic smoke. His paper, therefore, is chiefly a description of the various patented forms of household grates specially designed to minimize the evil. The Florence and Tropican grates are put forward as most successful in attaining this object. Towards the end of his paper Mr. Adams referred briefly to the perhaps more important subject of factory smoke, and emphasized once again the value of "little and often" as a system of firing, and the need for employing thoroughly trained and expert stokers. The Willskemp apparatus for "consuming" smoke is then referred to. This, in principle, is another adaptation of Williams' heated bridge air-supply, a small gas-producing plant being used in this case to keep the brickwork of the bridge at a high temperature. Thus, Adams' recommendations for smoke prevention are simply a repetition of the teaching of C. W. Williams and L. E. Fletcher, and may be summarized in the somewhat Irish proverb, "A good stoker is the best consumer of smoke."

CONCLUSIONS

In this brief summary of the contents of a few of the more important books and papers dealing with the smoke problem which have been published during the last sixty-five years, the writer may claim to have shown that there is an astonishing unanimity in the recommendations for minimizing the evil. It is little to the credit of fuel users, therefore, that so little real progress has been made in reducing the magnitude of this evil.

In spite of the fact that C. W. Williams pointed out clearly the path of reform over sixty years ago, factory chimneys belching forth clouds of black smoke are still far too common, and it is with a view to drawing attention once again to the teaching of these pioneers, C. W. Williams and L. E. Fletcher,—teaching which has the support of all the more recent writers on this subject,—that this article has been written.

Smoke is preventable according to those two authorities, even when burning bituminous fuels under the most trying conditions of use, and the method of preventing smoke is simply good stoking, with scientific control. The Hamburg society has contributed one important factor to the solution of the smoke problem, by showing how an adequate supply of trained and expert stokers can be obtained. Scientific control will be gained when factory owners and managers have been educated to see the necessity for, and value of, scientific aid in the management of their boiler plants.

At Hamburg this work has been undertaken by Herr Haier with such success, that already over 115 factory owners have joined the new organization, and have submitted the control of their plants to the engineering staff of the Smoke Abatement Society. It is along this line of voluntary organization among factory owners themselves that progress is now required, and the writer is hopeful that the example set by Hamburg may speedily be followed by many of the large industrial cities of Great Britain and of America.

PERPETUAL MOTION MACHINES

By F. Charlesworth, Assistant Examiner in the British Patent Office

IN the enlightened age in which we are living, one would almost expect that the idea of "perpetual motion" had ceased to occupy the minds of men, and that the hope of ever obtaining a machine which, once set in motion, would go forever, had been abandoned. This, however, is by no means the case, for inventors are still to be found who exercise their ingenuity in this direction.

The records of the British Patent Office show that, as recently as the years 1901, 1902, and 1903, there were, respectively, 13, 10, and 9 applications for patents relating to perpetual motion. From the year 1617, the date of the earliest patent, to the present time, the subject has received a fair share of attention, the number of applications for patents between the years 1617 and 1903 being over 600, of which only 25 have a date prior to 1855.

Out of a total of 31 applicants for patents during the years 1897 to 1900, inclusive, 10 were English, 8 American, 3 French, 5 German, 2 Australian, and 1 each from Russia, Belgium, and Austria.

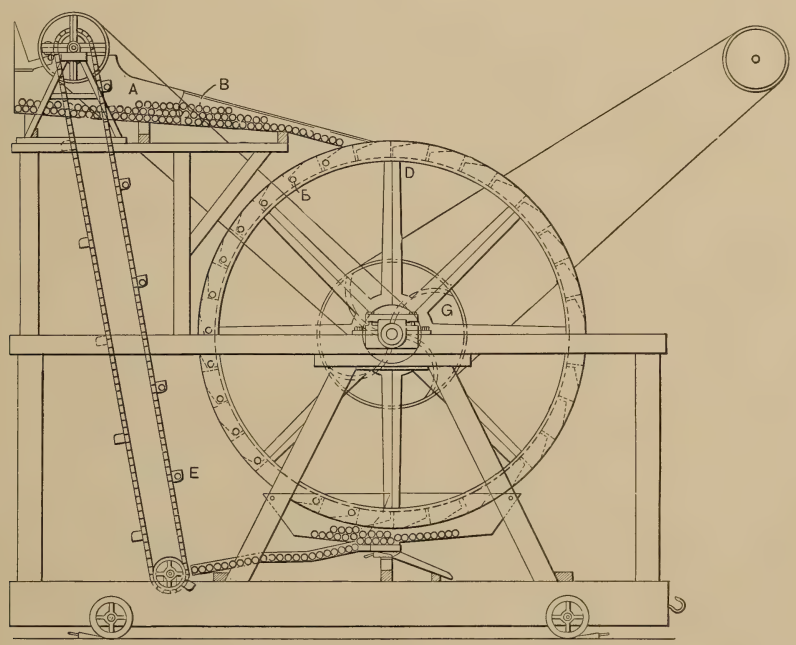


FIG. 1

In the many projects and schemes for obtaining perpetual motion, use is made chiefly of the force of gravity, loss of equilibrium, specific gravity of floats and weights immersed in water or other liquid, ascension of receptacles inflated with air or gas under water, compression and sub-

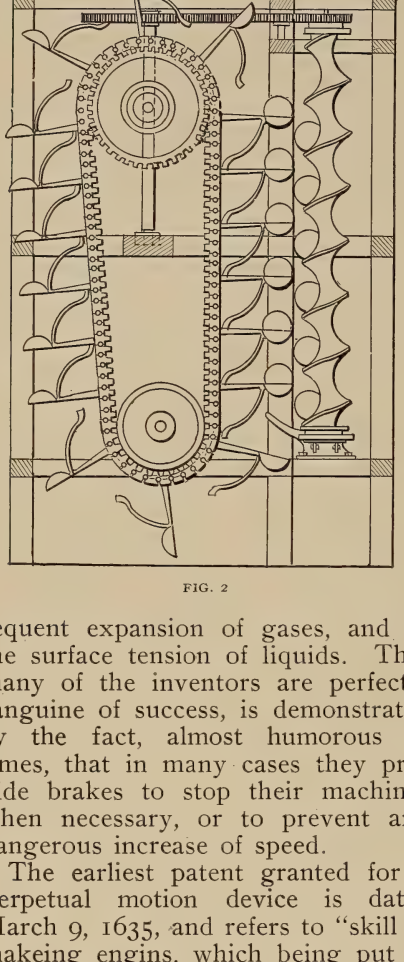


FIG. 2

sequent expansion of gases, and of the surface tension of liquids. That many of the inventors are perfectly sanguine of success, is demonstrated by the fact, almost humorous at times, that in many cases they provide brakes to stop their machines when necessary, or to prevent any dangerous increase of speed.

The earliest patent granted for a perpetual motion device is dated March 9, 1635, and refers to "skill of makeing engins, which being put in order, will cause and mainteyne their own mocions with continuance and without any borrowed force of man, horse, wind, river, or brooke, whereby many severall kinde of excellent rare worke may be pformed to the great good and benefitt of the comon wealth, the like cause and meanes of which continuance of mocion hath not been heretofore brought to pfeccion." We are left to guess what methods were adopted, as nothing is stated regarding them.

The second patent, granted in 1662, is very little better, a more definite statement, however, being made that it is a perpetual motion device, viz.:—"An engyne which, with the perpetuall mocion of itselfe, without the help or strength of any person or creature, will not only dreyne great levelle of vast quantities of water, but alsoe mynes of fifty fathom deep or more."

One of the commonest forms of perpetual motion machine is that in which a wheel *D*, Fig. 1, resembling a water-wheel, has cups or buckets on its periphery, each large enough to hold a wooden or metal ball *B*. The cups on the descending side of the wheel are fed with balls from an incline *A*, while those on the ascending side are empty, the difference in weight on the two sides being stated to produce rotation of the wheel. The balls roll out of the cups as they arrive at the lowest point of the wheel, and are lifted back to the incline by means of cups *E* on an endless belt driven from the wheel *D*. A pulley *G* and a belt are shown by which "motive power may be taken from the engine."

In a similar device, shown in Fig. 2, the balls fall into cups carried by an endless band. At the bottom, the balls are arrested by two horns, and are raised to the top again by a screw conveyor driven by spur gearing from the upper pulley over which the endless belt travels, a half-tube or guide rods being provided to make the balls rise vertically as the screw rotates.

Another ingenious method of rais-

FIG. 3

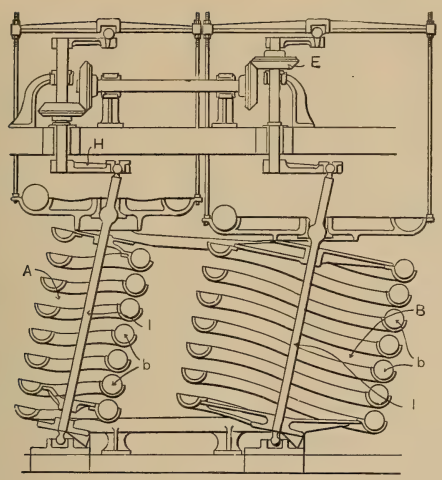


FIG. 4

ing the balls is to allow them, as they fall off the wheel, to "roll down an inclined plane or spout, enter a tall square or tube filled with quicksilver or some fluid, and, from their lightness, rise to the surface, to be lifted out by lifters (driven by the motor) and then rolled down another inclined plane or spout, and reload the wheel."

Another common form in which gravity is utilized is that in which weights on a wheel are free to move toward the periphery on the descending side of the wheel, and toward the center on the ascending side, the descending weights, by their leverage, tending to produce rotation.

In some cases the weights are pivoted on bell-crank levers *D*, as shown in Fig. 3. As the wheel rotates, the short arm of each lever engages a fixed guide *G* which turns the lever on its pivot and brings the weighted end on to one of the stops *I* within the periphery of the wheel. A brake strap *K* may be tightened upon the wheel rim by a screw *L* when it is required to stop the wheel. In other cases, weights in the form of rollers or balls are placed in peculiarly shaped grooves in the side of a wheel, the weights being supposed to roll toward the periphery on the descending side, and toward the center on the ascending side.

Another peculiar form is shown in Fig. 4. Two spiral tracks *A* and *B* of different diameters are arranged about axes *I* which are pivoted at their lower ends, and at their upper ends are connected to cranks *H*. Bevel gearing *E* connects the cranks so that the motion stated to be given to the track *A* as heavy balls *b* roll down it, is transmitted to the track *B* to raise the balls again. The balls roll from one track to the other along horizontal troughs. The large balls near the top of each track act as fly-wheels.

An arrangement for producing a perpetual oscillating motion is shown in Fig. 5, the various parts being here shown in one extreme position. A central oscillating bridge *D* carries a ball *X* which is capable of rolling on the bridge, and is connected by a telescopic tube *G* to the axis of two wheels *M*. These wheels are connected to a pair of balls *N* which run on a curved track *I*. When the ball *X* rolls to the position shown in dotted lines, the balls *N* roll up the track *I*, and the bridge *D* descends on the right; the balls *N* then roll back, bring back the ball *X*, and cause the bridge to descend on the left. A repetition of these movements keeps the bridge oscillating.

The buoyant motor, in which use is made of objects rising in liquids, has various forms. According to

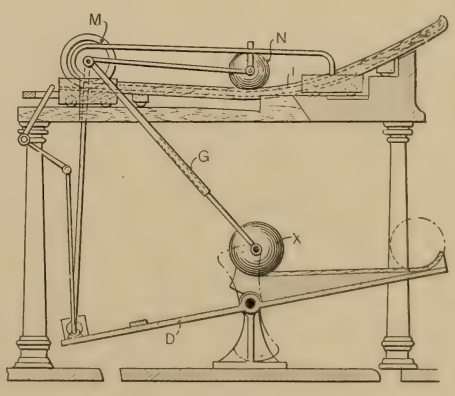


FIG. 5

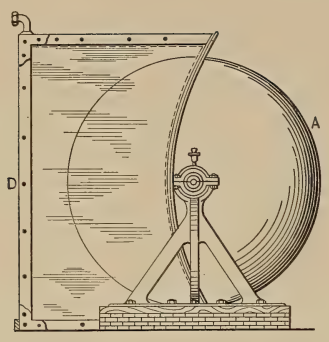


FIG. 6

one, a wheel with floats on its periphery, or a sphere or cylinder *A*. Fig. 6 is mounted so that one-half of it is in a tank *D* of water while the other half is outside the tank, or in a vacuum chamber. The upward pressure of the water on the part immersed in it produces rotation. If there is any difficulty about a fluid-tight joint where the wheel passes from the tank to the atmosphere, the whole wheel may be immersed in the water, the buckets or floats on the ascending half being

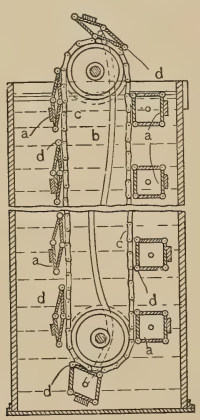


FIG. 7

extended or made buoyant, while those on the descending half are closed.

An example of this is shown in Fig. 7. The floats *a* on the endless chain *c* are made with hinged frames, and are loaded so as to collapse when descending. The stops *d* prevent them from collapsing when ascending. The floats may be connected in pairs by hose pipes *b* so that air may pass from one float to another.

An ingenious arrangement is shown in Fig. 8. A belt *e* has projecting blades *f*, and runs around the drums *d* in a reservoir of water. A number of floats are arranged to fall down a tube *o* and enter the spaces between the blades, the floats being guided by means of trunnions *m* sliding on guides *n*, and kept in their places by a second belt *h* driven from the shaft *c*. At the top, the floats

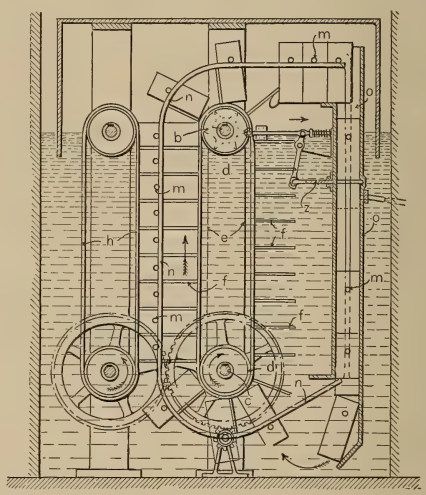


FIG. 8

move along a horizontal guide and drop into the tube *o*, falling upon a slide valve *z* which is actuated by a cam on the shaft *b* to allow the floats to fall through one by one. An air pump forces air into the tube below the valve each time the valve closes, thus forcing the lowest float out of the bottom of the tube.

Fig. 9 shows a very similar device, in which the weights or floats *A* descend in air on the right of the belt *C* and carry the belt with them. At the bottom they pass between rollers *G* into a tank *E* of water, and rise to the tilting table *L* to be again fed to the wheel *B* and belt *C*. The guides *J* and *D* keep the floats in position.

The arrangement shown in Fig. 10

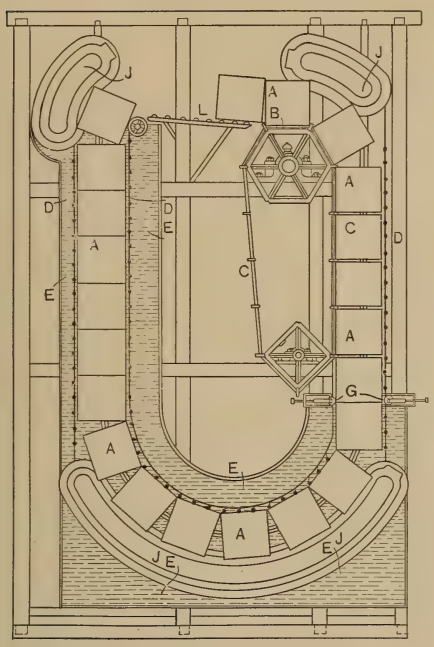


FIG. 9

is extremely ingenious. This consists of a drum *A* mounted on an axis *O* and provided with a ring of recesses *a* fitted with cylindrical plugs *b*. The drum is placed in a trough of mer-

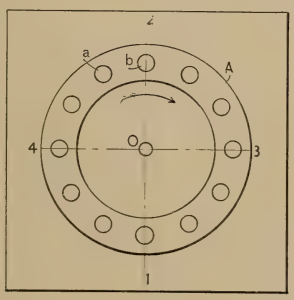


FIG. 10

cury. Means are provided to project the plugs on the side *3* and to withdraw them on the side *4*, the plugs being flush with the sides of the wheel in the positions *1* and *2*. The difference in pressure on the sides of the wheel is claimed to produce rotation.

Compressed air has been resorted to in various ways as a means of solving the problem of perpetual motion. In the year 1801, an inventor applied for a patent on compressing air into a receiver, then conveying the compressed air to a bucket wheel or to a piston, and the motor thus driven to compress more air into the reservoir for keeping up the motion.

A device for obtaining an inexhaustible supply of compressed air to drive a motor is shown in Fig. 11. The pipe *Qq* leads to the compressed air reservoir, and its upper end is slightly enlarged to a conical section. A cone *g* supported in a chamber *O* projects into the pipe *Qq*. Air under pressure is admitted to the chamber *O*, and, rushing into the pipe *Qq*, "will cause air from the outer atmosphere to be drawn in at the open ends of the pipe *Qq;* this is caused by the compressed air, in passing from the vessel *O*, rushing against the curved surface of the cone *g*. The centrifugal force of the air thus produced passes at right angles to the surface of the cone, and this causes the air to pass into the conical open end of the pipe *Qq* at an increased velocity to that at which it left the vessel *O;* the compressed air will consequently carry in air from the outer atmosphere, and thus will be supplied the air which is constantly passing off to work the engines."

Another compressed-air perpetual

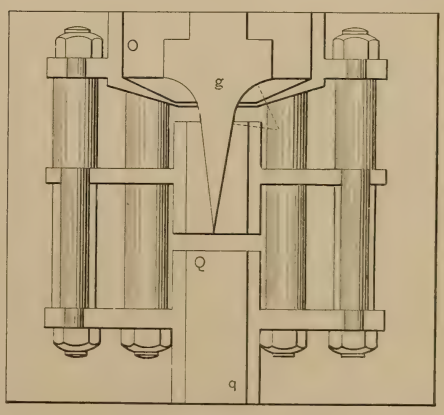


FIG. 11

motor is shown in Fig. 12. In this, compressed air or other elastic fluid is admitted to the chamber A^1 A^2, and its pressure against the larger surfaces S^1 S^2 produces rotary motion. The air is not exhausted, and the leakage losses are made up by pumps driven by the motor. A block D having numerous rectangular cells receives the reactive force of the fluid.

Other inventors propose to utilize the weight of railway carriages, tram cars, etc., to compress sufficient air to drive them, or to construct the tires of a cycle so as to compress air in sufficient quantity to drive the motor which, in turn, will drive the cycle.

The water-wheel, pump, and other hydraulic apparatus have not escaped

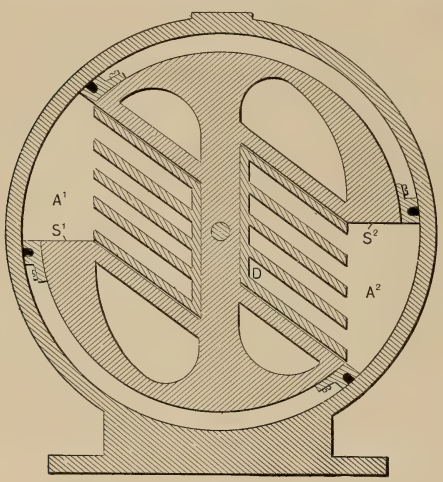


FIG. 12

the notice of those anxious to solve the problem of perpetual motion. A common motor of this type, and one that has been invented more than once, is that shown in Fig. 13, in which a water-wheel D is driven by water from a tank R, and in turn operates the bucket elevator shown to again raise the water up to the tank.

Another inventor proposes to combine the water-wheel, turbine, and centrifugal pump as shown in Fig. 14. The water, after leaving the

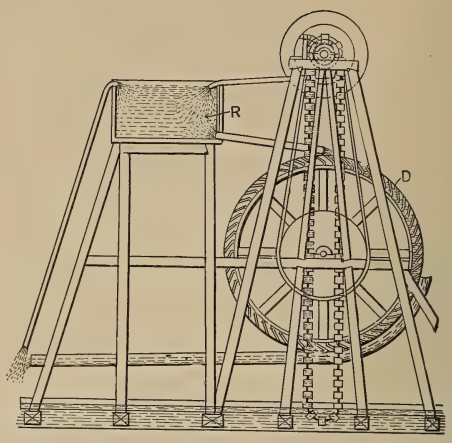


FIG. 13

wheel A, drives the turbine I, and the pump G is driven from the wheel A to raise the water again to the top of the wheel. The power is taken both from the wheel and the turbine.

In the motor shown in Fig. 15, the pump A drives a water-wheel by discharging water upon it, and the wheel in turn drives the pump. A brake is provided to prevent any dangerous increase of speed, and a fly-wheel B is also provided for starting purposes.

An ingenious device, invented as recently as 1900, is shown in Fig. 16. Here a drum b with folding vanes c is driven by water flowing alternately into the chambers d and e, a vacuum being produced in the chambers by a screw t. Valves l and m, worked simultaneously, open and close the

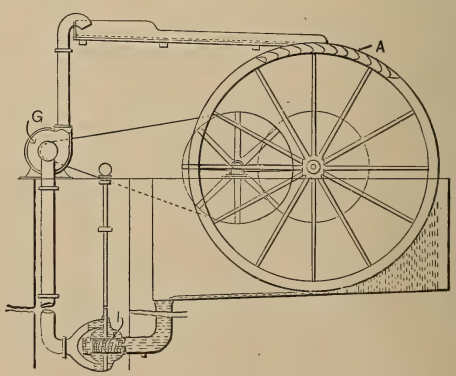


FIG. 14

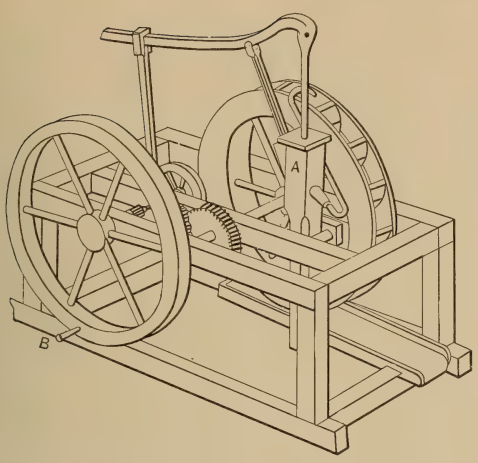


FIG. 15

chambers, one chamber being open at the top while the other is open at the bottom, and vice versa.

Springs arranged to be rewound by the motor have been used in some forms of perpetual motion machines. An example, stated to be used for driving tram cars, motor cars, sewing machines, and other light machinery, is shown in Fig. 17. A coiled spring in a box *A* has one end secured to the box and the other end to the shaft *C*. The spring rotates the shaft. A wheel *P* transmits the motion to a compound wheel *N* which rotates around a fixed wheel *G* and is also geared to a wheel *O* which rotates a worm-wheel *H*. This wheel *H* carries a frame *J* supporting bevel gearing *F* which gears with a wheel *D* on the box *A* and rewinds the spring.

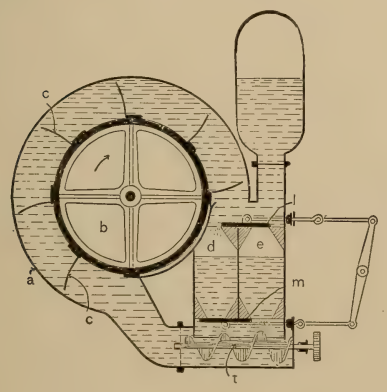


FIG. 16

In addition to the various types of motors previously described, there are many others more or less ingenious. One of these is operated by the surface tension of liquids. A rocking beam pivoted at the center has its two ends overhanging two mercury troughs. A bundle of thin metal plates hangs from each end of the beam, and the plates are immersed in the mercury. Means are provided for varying alternately, on each side of the beam, the area of the plates in contact with the mercury, so that the increase of surface tension as the area increases produces a rocking of the beam.

Another inventor makes use of capillary attraction. A pair of flywheels *a b*, shown in Fig. 18, are mounted in a tank containing a liquid. The liquid is claimed to rise between the wheels, at the parts close together, in sufficient quantity to rotate the wheels by its weight.

There is an invention based on the

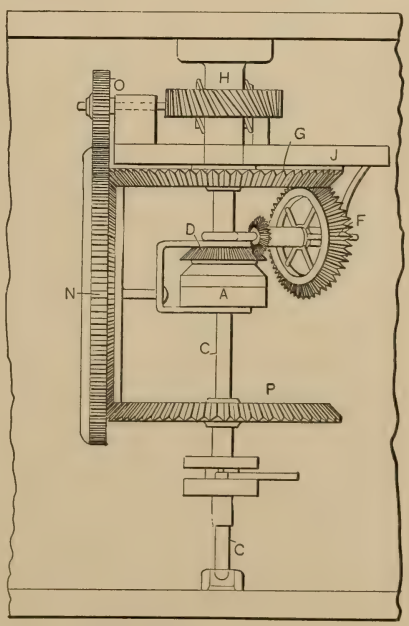


FIG 17

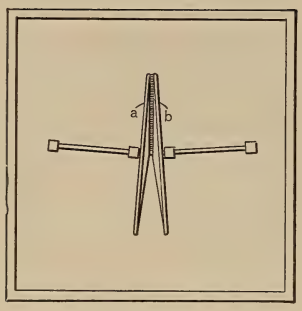


FIG. 18

principle that "if a frictionless or nearly frictionless piston is shot by atmospheric pressure and energy into a cylinder in which a vacuum exists, the force of impact, after the piston has traveled a short distance and strikes a solid surface, is greater than that required to bring back the shot piston to its original position." Two cylinders are used, each provided with a shot piston and with a second piston for receiving the impact through an air-buffer arrangement to drive the shaft. The pistons are connected to the moving parts of the engine to return them to their original positions.

Another idea is that of having a high-speed electric motor, started by an accumulator, to store up mechanical energy in fly-wheels, and by means of reducing gearing, to drive two slow-speed dynamos, which are stated to generate sufficient current for external work and to supply the motor.

In another arrangement, a vapour engine drives compressors which compress gas and pass it through cooling tubes to be liquefied. The liquefied gas is pumped into a reservoir and is again evaporated at atmospheric pressure to drive the vapour engine.

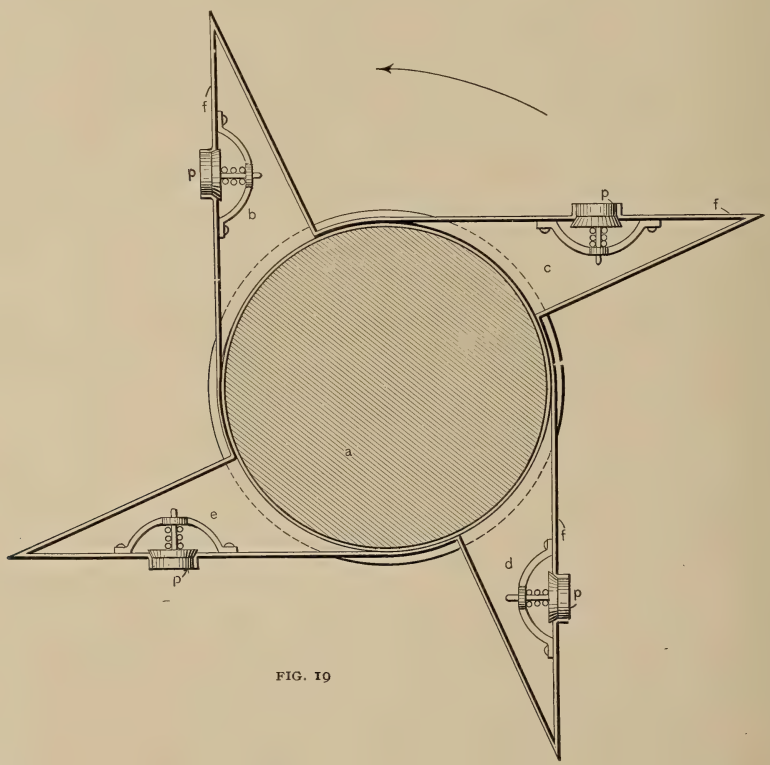


FIG. 19

Another invention is stated to depend upon a revised statement of the first and second laws of thermodynamics, and to consist of a special

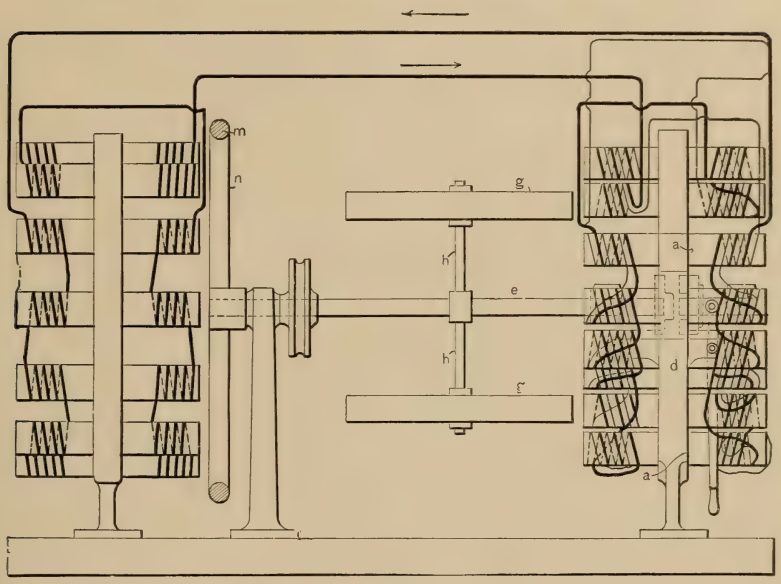


FIG. 20

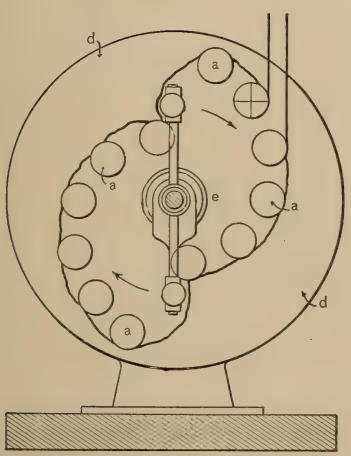


FIG. 21

cycle of working in which the heat rejected in the Carnot cycle is intercepted and returned to the source, thus making it possible to convert into motive power the diffused heat at ordinary temperatures that exists in the atmosphere or elsewhere.

The motor shown in Fig. 19 was invented in 1902. The vessels *b*, *c*, *d*, and *e* are mounted on a shaft *a*, and have one side *f* tangential to the shaft, and the other side radial. Compressed air is forced into each vessel through the valves *p*. It is stated that "under the action of the internal pressure of the vessels, and after a slight impulse has been given to same, in the direction of the arrow, the whole apparatus will begin to move and continue to do so without ever stopping, the velocity corresponding to the pressure established within the vessels."

The magnetic motor is another form of perpetual motion machine. A good example, invented in 1894, is shown in Fig. 20. A series of permanent magnets *a* are mounted on a fixed frame *d* so as to form two semi-circles eccentric to the shaft *e*, and the like poles of the magnets

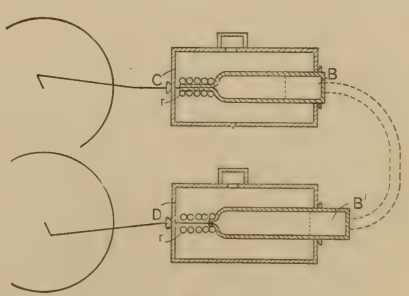


FIG. 22

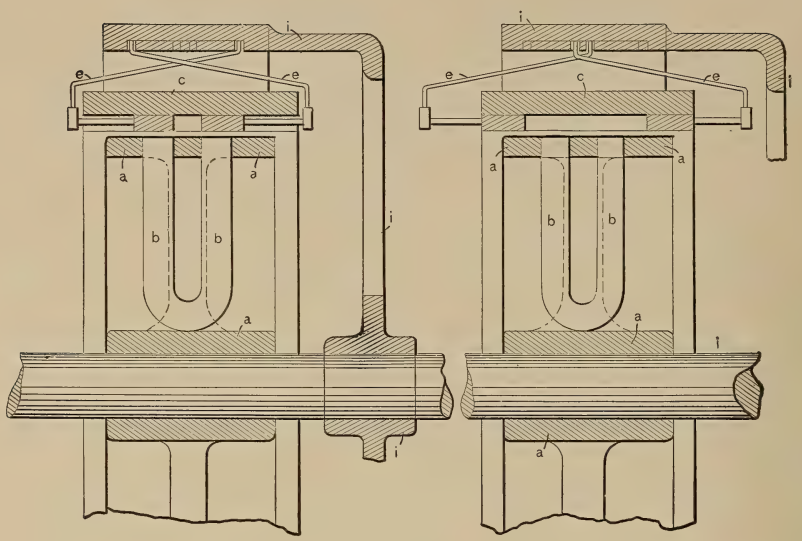


FIG. 23

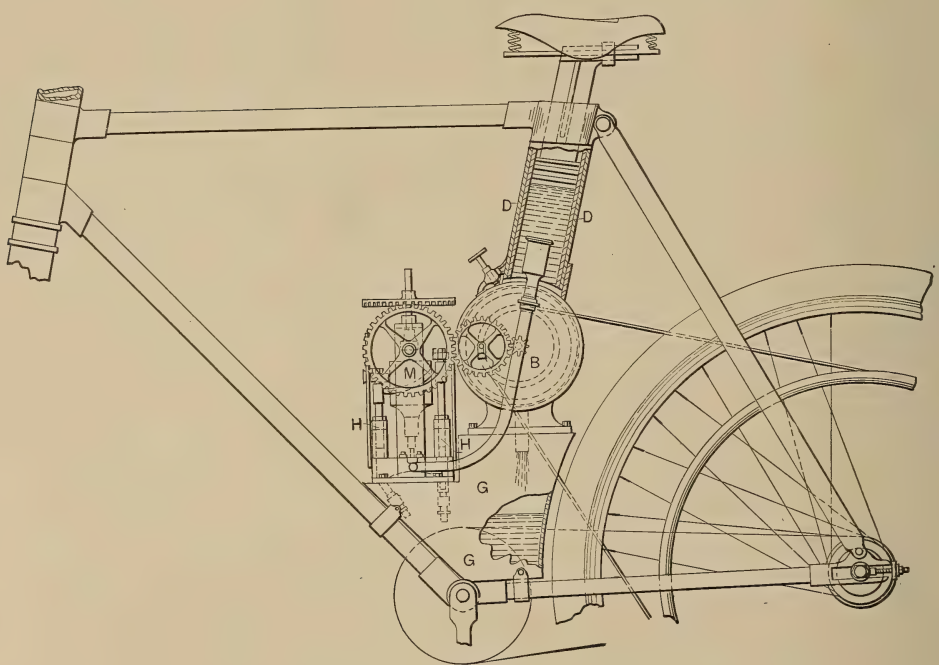


FIG. 24

face one way. Two permanent magnets *g* are mounted on arms *h* on the shaft, their similar poles facing toward the magnets *a*. The action of the magnets *a* causes the magnets *g* to rotate as shown in the end view, Fig. 21. The magnetization of the magnets *a* is increased by means of the windings shown, current being generated in the coils by means of an armature *n*. The armature is carried by a wheel *m* on the shaft *e* which rotates in front of the magnets *i*.

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Another form is shown in Fig. 23. A wheel *a* is fitted with a number of permanent magnets *b*. Around the wheel is a fixed ring *c* fitted with iron blocks sliding in grooves and moved by means of rods *e*, the opposite ends of which run in cam grooves in a wheel *i* mounted loosely on the shaft. On turning the wheel *i*, the blocks slide successively into the positions shown in the two figures, and rotate the wheel *a*.

A peculiar motor is shown in Fig. 22. Two pistons *BB'*, capable of collapsing, work in opposite directions in the cylinders *C D* and communicate with each other. The inner ends of the pistons are flattened to pass between the rollers *r*, and when flattened, are of the same section as the piston-rods by which they and the connecting-rods are connected to the cranks shown, so that, as the pistons move in and out, no displacement takes place in the cylinders. In operation, one cylinder is first opened to a source of pressure and the other cylinder to the atmosphere. The piston in the cylinder under pressure moves outward, the other piston moves inward, and the liquid in one piston passes to the other. The cylinder originally open to the atmosphere is now opened to the source of pressure, the other cylinder is opened to the atmosphere, and the reverse motion of the pistons ensues. These operations are repeated continuously to produce perpetual motion.

The motor shown in Fig. 24 should be particularly interesting to motor cyclists, for all expense in connection with petrol, electricity, and other sources of power is thereby removed. The weight of the rider on the saddle places a pressure on the water in the hollow bar *D*. This water passes through nozzles and drives a turbine wheel *B;* it then passes to a chamber *G* from which it is pumped back to the bar *D* by pumps *H*. The pumps are driven from the wheel *B* through the spur gearing shown, the vertical spindle *M* having a cam groove into which blocks on each pump rod engage. The cycle is driven by a belted connection with the turbine.

From the foregoing examples, it is evident that much ingenuity and thought have been spent upon the subject of perpetual motion, and that in many cases it would be foolish to suppose that the inventors are cranks; on the contrary, the care and thought as to principle and detail in many of the inventions, demonstrate that many men still cling to the idea that perpetual motion is possible, and that they themselves are successfully solving the problem.

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NIAGARA RIVER BELOW THE FALLS

PIPE-LINE POWER IN NIAGARA GORGE

By Alton D. Adams

LOWER Niagara River falls eighty feet in a length of two and a half miles, with the Whirlpool located nearly at the center of this length. This descent is substantially half as great as that at the great cataract above, and is made by the entire volume of water that passes over both the American and the horseshoe falls.

It follows that the unused power of these rapids just above and below the Whirlpool is one-half as great as could be developed by diverting the entire flow of Niagara River at the falls, and leaving the face of the cliffs over which the rapids now plunge, dry and bare. All power developments on Niagara River thus far have been carried out by diverting water a little above the Falls and discharging it just below, because of the small investment per unit of power on this plan. So much water has already been granted for power purposes above the cataract, that further concessions must be limited mainly to the gorge and lower rapids, if the American Falls are to be saved.

A distinction in this respect is to be made between the American and Horseshoe falls, because the rock-crest of the former and the bed of the river above are some feet higher than the corresponding crest and bed at and above the Horseshoe falls. For this reason the result of a continued increase in the volume of water di-

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WHERE PIPE-LINE POWER MIGHT BE DEVELOPED

verted from the upper river by canals, pipe lines and tunnels, will be to lay bare the channel between the New York bank and Goat Island, while a large volume of water will still pass over the Canadian Falls.

Power developments along the rapids above and below the whirlpool will probably cost somewhat more per unit of capacity than they would close to the falls, but even at the rapids the investment per horsepower will be much lower than that on many ordinary rivers. The necessary amount of investment per unit of plant capacity along the rapids will vary with the type of development adopted. Any one of at least four types of power development may be followed in the gorge.

One plan is to construct canals between higher and lower parts of the rapids, but as the Niagara plateau rises as much as 200 feet above the river level in the gorge, this plan seems to be impracticable. It is true that by a large amount of rock excavation a canal might be constructed along the faces of the nearly perpendicular cliffs that form the sides of the gorge, but the expense would be nearly equal to the cost of tunnels. Tunnels also may be drilled through the cliffs from point to point along the rapids, and this is one of the entirely practicable methods of developing the power. Still another plan that promises well for economy of construction is that of pipe lines between upper and lower points on the rapids.

By looking along almost any part of the gorge it may be seen that the cliffs on either side are nearly perpendicular near their tops, and that their faces often incline at angles of not more than 45 degrees up to elevations of 50 or 100 feet above the river. This lower portion of the cliffs takes its shape more or less from the talus that, during past ages, has fallen from the rocks above. For the purpose of power development by pipe lines in the gorge, this change of slope along the lower parts of the cliffs is fortunate, because a cheap

and convenient means of support is thus provided from point to point along the rapids.

The power of the rapids may be developed under a head of water of from less than twenty to fully eighty feet, by means of pipe lines, but the larger heads will yield greater powers at a lower investment per unit of capacity, because the power that can be developed with a certain volume of water per second discharged by a pipe of given size varies directly with the head. As Niagara River changes its direction 90 degrees at the whirlpool, and as the whirlpool lies in an indentation of the Canadian bank, a given head of water can be obtained with a pipe line of shorter length on the New York side.

The general plan for any such pipe line would be to locate its upper end a little below the water level, lay the pipe along the face of the cliff until it reaches a point down stream where the power is to be developed, and there to connect it with the wheels by suitable penstocks. In each case the effective head on the water wheels would be the difference of river levels between the upper end of the pipe and the tail water, minus the loss by friction in the pipe.

Starting from a point about 500 feet up stream from the cantilever railway bridge, on the New York side of the river, a pipe line might be laid along the face of the cliff down to the point of land just opposite the whirlpool, a distance of about 6000 feet, and the total head of water thus obtained would be as much as 51 feet. If this pipe line were carried on around the point opposite the whirlpool, and down stream for a distance of approximately 7000 feet from that point, making the total length 13,000 feet, a water head of fully 80 feet would be obtained. On the Canadian bank of the river, a line of pipe 6000 feet long, from a point 500 feet above the cantilever railway bridge, to the upper side of the whirlpool, would make available a head of 51 feet of water. If this line of pipe were carried on around the whirlpool and down stream to a point 7000 feet below the latter, the total head developed would be fully 80 feet, and 17,000 feet of pipe would be required.

The power that might be developed by either of these pipe lines depends, of course, on the volume of water passing through it, and on the loss of head in the pipe. Niagara River has a normal discharge of 222,000 cubic feet of water per second, and this water falling 80 feet develops 2,000,000 gross horse-power. Making due allowances for losses in the pipe line, water wheels, tail race and generators, it may fairly be said that 60 per cent. of the gross energy of the water, or 1,200,000 H. P., could be delivered as electric current if the entire discharge of the river were utilized. This net power is twice as great as that of all the electric plants now completed and under construction at Niagara Falls.

If the entire discharge of the river, or even the larger part of it, were to be diverted by pipe lines as suggested, it would be necessary to build a dam near the cantilever railway bridge, to maintain the head of water. Such a dam, when all the water was passing through the pipe lines, would lay bare the bed of the river for two and one-half miles, except at the whirlpool, and the latter would become as quiet as a mill pond. With a division of enough water to develop at least several hundred thousand horse-power, no dam near the railway bridges or elsewhere would be necessary.

The pipe lines suggested might well deliver water directly to the penstocks of separate sets of wheels without the intervention of a forebay, and their cost per unit of power capacity would be moderate. Instead of presenting merely the results of computations to show the size and probable cost of a pipe line for a given power capacity, an illustration may be taken from one of the large plants now under construction at Ni-

agara Falls. Water for the operation of this plant is to be conveyed from a forebay on the upper river above the rapids to a point a little below the falls by steel pipes which have an inside diameter of 18 feet. From these pipes, penstocks run down to the several sets of water-wheels. The distance between the forebay and the nearest penstock that joins one of these 18-foot pipes, is 6180, and the distance to the most distant penstock is nearly 7000 feet. Each of the 18-foot pipes is designed to deliver about 3900 cubic feet of water per second at times of full load, thus giving the water a velocity of 15.3 feet per second in the pipe.

When delivering water at this rate through a length of between 6000 and 7000 feet, the loss of water head due to the friction of each pipe is estimated at 20 feet, or about 3 feet loss of head in every 1000 feet of the pipe. This loss of head is not excessive under the conditions where the 18-foot pipe is to be used, because the total available head of water there is more than 200 feet; but for pipe lines in the gorge where the total available head is but little more than 80 feet in 2.5 miles of rapids, a loss of 3 feet of head in every 1000 feet of pipe would be too great.

A well-known law governing the flow of water in pipes is that the loss of head due to friction varies as the square of the velocity of the water. According to this, if the velocity in one of these 18-foot pipes is reduced to 9 feet per second, the loss of head will drop to about 1 foot in 1000 feet of length. Good turbine wheels and electric generators have a combined efficiency of as much as 72 per cent. at full load in the large sizes that would be used for power development in the gorge. With a total efficiency of 60 per cent. in the entire water power development, the combined efficiency just named for turbines and electric generators allows a loss of 16.6 per cent. of the available water pressure in the pipe line. This percentage of the water head of 80 feet that would be made available by a pipe line 13,000 feet long on the New York bank, as previously mentioned, amounts to 13.2 feet.

Since a velocity of 9 feet per second in the 18-foot pipe causes a loss of head of only 1 foot per 1000 feet of length, the line 13,000 feet long will consume a water head of 13 feet in friction, and the entire power development under these conditions will have an efficiency of 60 per cent. A pipe of 18 feet internal diameter, through which water flows at a velocity of 9 feet per second will discharge 2286 cubic feet of water per second. This water, under a head of 80 feet, develops a total of 20,600 H. P., and as the pipe line, turbines, and generators have a combined efficiency of 60 per cent., the 18-foot pipe with its head will supply water for the development of substantially 12,000 electric horse-power. This is the power that might be developed by a pipe line 13,000 feet long on the New York side of the river.

On the Canadian bank, the length of pipe line to make available a head of 80 feet has been found to be 17,000 feet, and the power developed with an 18-foot pipe of this length would be somewhat less than that just found, or else the efficiency of the pipe and plant would be lower.

It may be noted here that in any of these cases the power that can be developed from water in a pipe of given diameter under a certain head, increases with the loss of head in the pipe, up to a certain point, but at the expense of efficiency.

The velocity of the water in either of the pipe lines that develops a head of 51 feet with a length of 6000 feet, as previously mentioned, may be taken at 10 feet per second, and then the loss of water head in the 18-foot pipe will be 1.3 feet per 1000 feet of length, on the basis of a loss of 3 feet in head with a velocity of 15 feet per second. At this rate, the

water head lost in the pipe line 6000 feet long on either the New York or Canadian bank of the river would be 7.8 feet.

As a loss of 16.6 per cent. of the total head in the pipe allows a combined efficiency of 60 per cent. in the water power plant, the velocity of 10 feet per second in the 18-foot pipe 6000 feet long, under a head of 51 feet, will give a slightly higher efficiency.

This velocity of 10 feet per second corresponds to a discharge of 2540 cubic feet of water through the 18-foot pipe in that time, and this water, under a head of 51 feet, develops 14,602 horse-power. With a total plant efficiency just above 60 per cent., the electric power developed by the water discharged from this pipe reaches 8800 horse-power.

Where these 18-foot steel pipes are laid at Niagara Falls, the water pressure at their upper ends is 19 feet, and at their lower ends 47 feet, and the steel plates used to form the pipes are ½ inch thick. The 47-foot pressure is greater than that to which it would be necessary to subject 18-foot pipes laid in the gorge, to utilize the power of the rapids, because penstocks would properly extend from the turbine wheels to the 18-foot pipe some distance above, so that this main pipe would be subject to much less than the entire head of water.

It may be assumed that 18-foot pipes in the gorge would be made of ½-inch plates, even though these would give an excess of strength. The weight per linear foot of pipe of this thickness is about 1200 pounds. For the line of 18-foot pipe 6000 feet long, the weight would, therefore, be 7,200,000 pounds approximately, and for the pipe line of 13,000 feet the weight would be 15,600,000 pounds. On the 18-foot pipe now in position at Niagara Falls, there are 8-inch steel deck beams riveted to the upper half of the outside surface at intervals of four feet along the entire length, but in the case of the gorge the use of these deck beams would probably be unnecessary.

If the cost of these steel pipes erected in the gorge is 3 cents per pound, the investment in the 18-foot pipe line 6000 feet long would be $216,000, and the investment in the line 13,000 feet long would be $468,000. As the 6000-foot pipe line would have a capacity for 8800 electric horse-power, and the 13,000-foot line a capacity for 12,000 horse-power, on the basis previously considered, the investment per horse-power of capacity would be $24.54 for the shorter pipe, and $39 for the longer pipe. These figures are certainly much below what the value of the power would warrant, if necessary.

Similar results in the matter of power development along the rapids may be obtained with both pipe lines and tunnels, and it is therefore desirable to compare the investments necessary under the two methods. As all other factors may well be substantially the same, this comparison should relate merely to the costs of pipe lines and tunnels per unit of power developed with a given efficiency.

If the entire water head available at the rapids is to be utilized, tunnels have some advantage over pipe lines in the matter of length, because the former can be drilled on straight lines, while the latter must follow the course of the gorge. Thus, to make available the head of 80 feet, a pipe line must follow the two sides of a triangle along the bank of the river, while a tunnel may be excavated along a straight line that forms the third side, between points on the New York bank. On the Canadian side of the river, the length of a pipe line need not exceed that of a tunnel by more than 2000 feet for the 80-foot head. In New York, the head of 80 feet, developed by the pipe line 13,000 feet long, could be made available by a tunnel with a length of 10,000 feet.

For comparison with the 18-foot pipe line already considered, to develop the head of 80 feet along the rapids, there may be taken a tunnel, like that now used to convey water from a point above to one a little below the horseshoe falls. This tunnel is of the horseshoe form, with a height of 25 feet and a maximum width of 19 feet; it has a descent of 7 feet in each 1000 feet of length, and is designed to discharge 8900 cubic feet of water per second. To maintain an equal rate of discharge through a tunnel of this cross-section, and 10,000 feet long, the corresponding loss of water head would be 70 feet, but in this tunnel, as in the pipe line 13,000 feet long between the same points, the loss of head is limited to 13 feet.

As the loss of head due to the friction of a pipe or conduit varies with the square of the velocity of the water flowing through it, the velocity in the tunnel 10,000 feet long will be 0.43 of the velocity in the existing tunnel of the same cross-section that descends 7 feet in each 1000 feet of its length. The existing tunnel is designed to discharge 8900 cubic feet of water per second, and on this basis the proposed tunnel of equal cross-section, but with a descent of 13 feet in 10,000 will discharge water at the rate of 8900 x 0.43 = 3827 cubic feet per second. It was found that the 18-foot pipe line 13,000 feet long would discharge 2286 cubic feet of water per second, with a friction loss of 13 feet in head, and it thus seems that the proposed tunnel would discharge 1.67 times as much as the pipe line with the same loss.

The existing tunnel at the falls, with a finished height of 25 feet and a width of 19 feet, is lined below its center with a layer of concrete faced with vitrified brick having a total thickness of 22½ inches, and above the center with timbers and brick to a thickness of 31½ inches. From this it appears that the necessary excavation for such a tunnel amounts approximately to 22 cubic yards per foot of length.

It also appears that, at the present prices of tunnel work about Niagara Falls, the cost of the finished tunnel under consideration would be approximately $5 per cubic yard of the necessary excavation. On this basis, the proposed tunnel would require an investment of $110 per linear foot, or $1,100,000 for its entire length of 10,000 feet.

The 3827 cubic feet of water discharged per second by this tunnel would develop 34,500 H. P. under the head of 80 feet, and with a combined efficiency of 60 per cent. for the tunnel, wheels, and generators, the output of electric power would be 20,700 H. P. With this output, the estimated investment in the tunnel would represent $53.14 per horse-power capacity of electric generators.

As the estimated cost of the 13,000-foot pipe line was $39 per horse-power capacity of the electric plant, it appears that the tunnel would cost 36 per cent. more for the same capacity and efficiency than a line of steel pipe, in spite of the greater length of the latter. Against this lower first cost must be entered the fact that the depreciation would be larger for the steel pipe than for the tunnel. Either pipes or tunnels offer an entirely practicable means of developing power in Niagara gorge.

DREDGING AND DREDGING APPLIANCES

PART II.—GRAB OR GRAPPLE DREDGERS AND SUCTION DREDGERS

Part I., in the November Number, was Devoted to Ladder and Dipper Dredgers

By Brysson Cunningham

CLOSELY allied to the ladder and dipper dredgers is the grab or grapple dredger. All three varieties possess essentially the form of a scoop or bucket, but whereas the action in the two former types is entirely that of scraping or scooping, in the last-named type there is also a clutching movement. Accordingly, grab dredgers consist of two or more curved plates or jaws capable of opening and closing in a fashion not dissimilar to the working of the human mouth or of the hands in taking up a quantity of grain. Most frequently, the section of a grab comprises two circular quadrants capable of rotating about a central pivot, the whole forming when closed a semi-cylindrical receptacle. But oftentimes, especially for well-sinking purposes, which, however, lie outside our present purview, grabs possess the form of a hemispherical shell, in three or four segments.

The grab dredger is worked to a very large extent by the aid of gravity. Suspended by a chain or chains, from the head of a crane jib, the bucket is allowed to fall freely by its own weight, with open jaws, until it buries itself in the ground to an extent dependent upon the nature of the material. The jaws are then brought together by means of the tension imparted to the chain or chains by the winch, and the enclosed mass of earth is lifted and removed in the ordinary way.

The principle of the grab is simple, but there are complex adaptations of it in actual practice. Thus, in the first place, the appliance may be operated by one or two chains. Each of these systems admits of several arrangements, so that there are a number of machines on the market possessing distinct characteristics, each class being admirably adapted to a particular purpose. Too much space would be occupied in referring to all these different machines, so we must content ourselves with adverting briefly to the more noticeable of them.

Thus, the Peters grab, shown in Fig. 1, is a single-chain machine, the working of which depends upon the gripping of the lifting chain, prior to the opening process, by a pair of steel arms, which are actuated and controlled by a roller bearing against the chain, and a governing rod attached to the upper edge of the bucket. In excavating, the bucket is closed by the chain which continues taut during lifting. When the chain is slackened, the roller falls and allows the grippers to engage. Then, on hoisting again, the grab is pulled open.

The Wild grab, shown in Fig. 2, also has a single chain fitted with a catch in the form of a half ball, or hemisphere, with the flat surface uppermost. Such a form permits the downward passage of the catch between two small tumblers, but prevents it rising again and the grab from closing until the bottom is reached, when the chain becomes slack and the tumblers are automatically opened by the weight of a

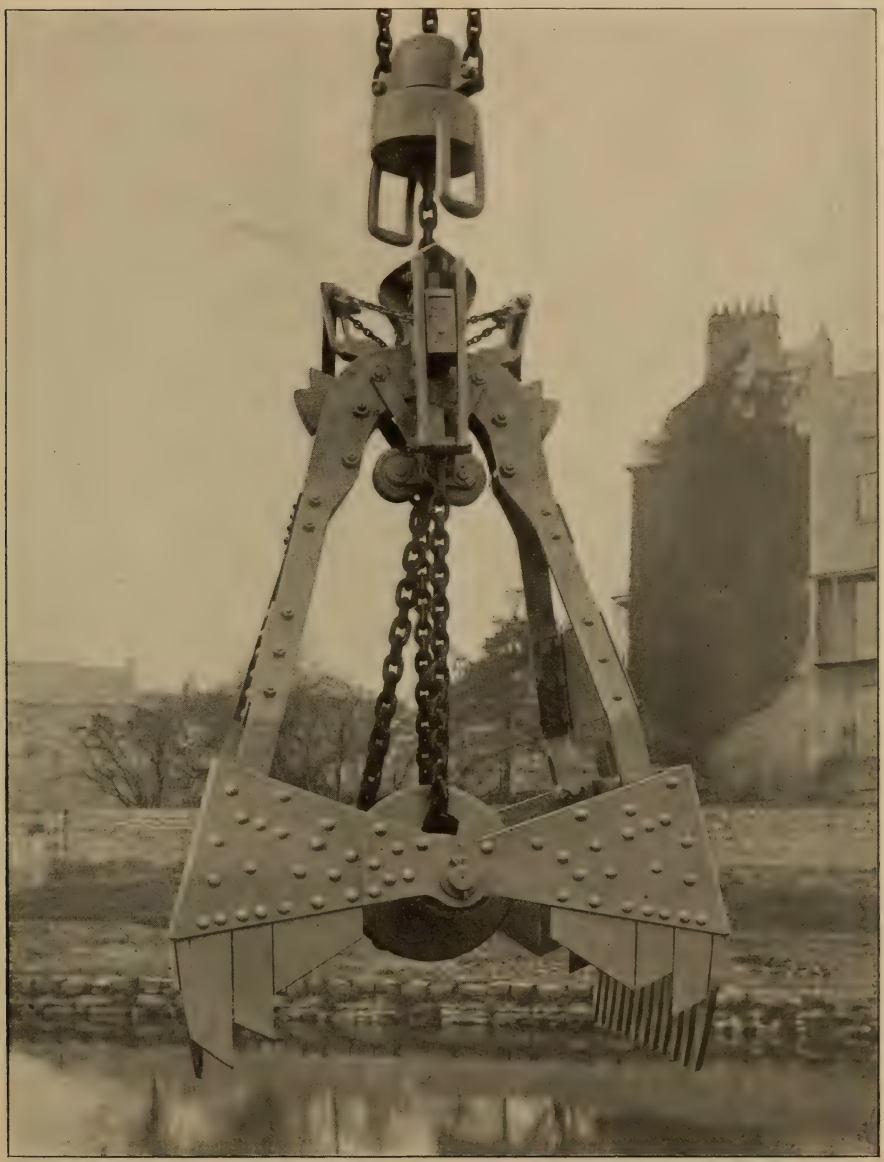


FIG. 1.—THE PETERS GRAB MADE BY MESSRS. STOTHERT & PITT, LTD., BATH, ENGLAND

sliding sleeve. The grab can then be closed and drawn up until it reaches a position where a ring in the lifting gear engages two steel hooks, from which the grab is suspended during discharge. A simple mechanical contrivance causes the hooks to be withdrawn again when the grab is slightly lifted prior to making a fresh descent for reloading.

A very important difference between the two single-chain machines just described and one materially affecting their respective efficiencies is that whereas in case of obstruction or in case of an imperfect or ineffective lift, the Peters machine can be opened at

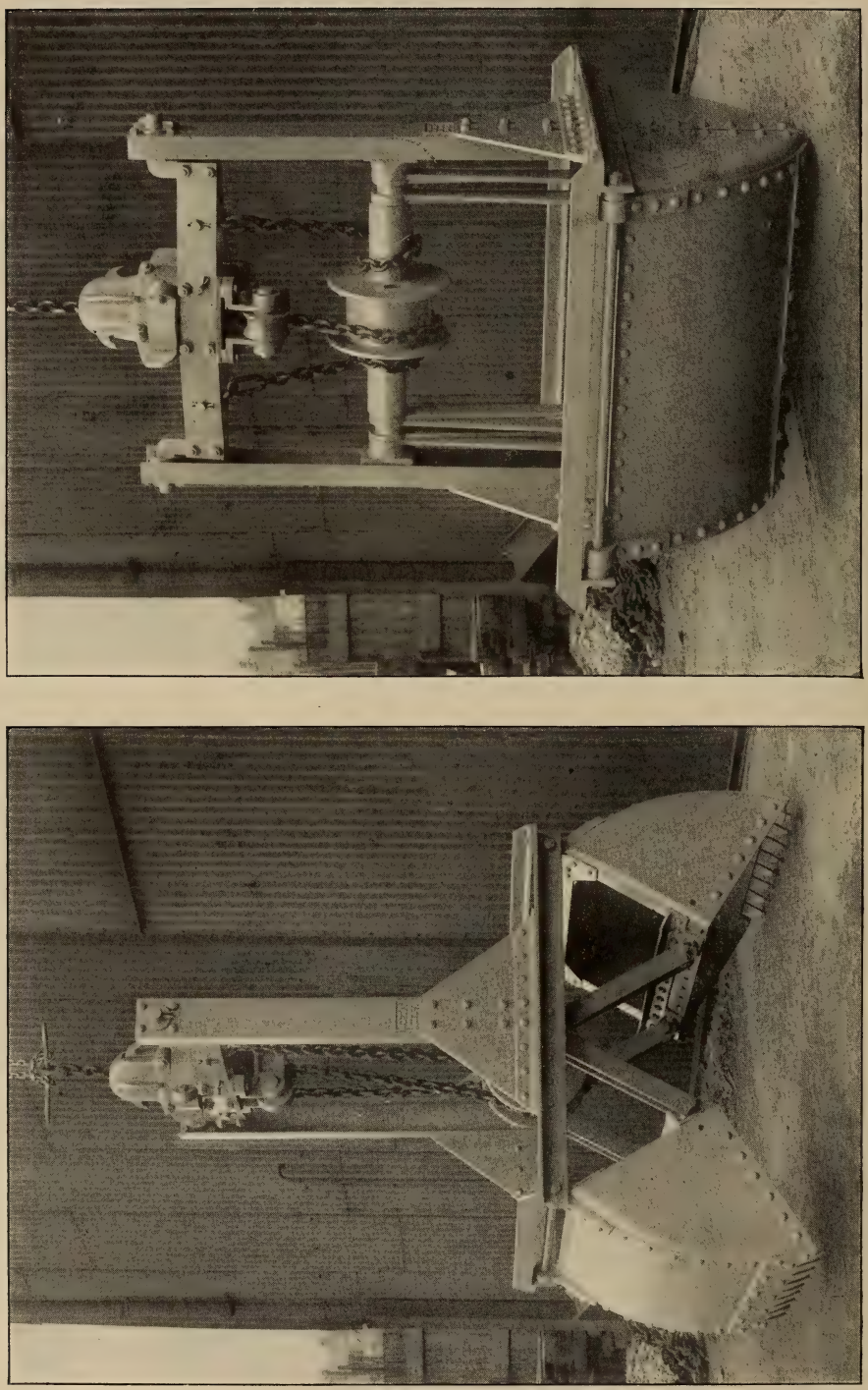


FIG. 2.—WILD'S GRAB, OPEN AND CLOSED. MADE BY MESSRS. STOTHERT AND PITT, LTD., BATH

any stage, the Wild grab, and, indeed all other single-chain grabs within the writer's knowledge, have necessarily to be lifted to the full height of the suspending gear before discharge can take place. If the grab should close upon some immovable object below water, only with the Peters system could it be made to relax its grip without lowering the suspender or without the aid of a diver.

This advantage of the Peters grab is shared by all double-chain grabs, but they, on the other hand, cannot be fitted as can single-chain grabs, to an ordinary crane, requiring as they do a special form of jib head and gear. Yet this is but a single drawback, and there are many strong points in favour of double-chain grabs. They possess fewer, less delicate and less intricate working parts, and so do not run as great a risk of getting out of order, nor do they require such skilled attention. They provide a much better safeguard against the loss of the bucket,—a consideration of some importance in submarine work. Where the bucket is upheld by two chains there is not only less chance of its being carried away altogether, but risk of breakage to either chain is materially lessened. Finally a double-chain grab can discharge its load as gradually as may be considered desirable, whereas the action of a single-chain grab is instantaneous and complete.

The Priestman grab, shown in Fig. 8, belongs to the double-chain system. The outer corners of the bucket are connected by hinged arms to a horizontal bar or cross-piece, which is capable of vertical movement in the central groove of the frame. From the jib head, one chain is attached to this bar, and any tension on the chain causes the bucket to open; the other chain is wound around a drum on the pivot, and its unwinding, with the assistance of two subsidiary chains connected to the horizontal bar previously mentioned, draws this bar down and causes the bucket to close.

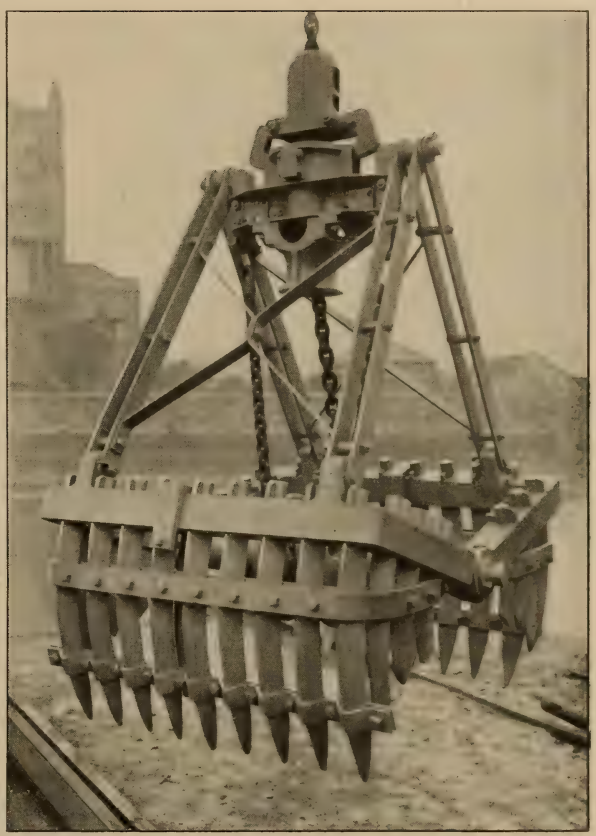


FIG. 3.—WILD'S GRAB FOR HANDLING BROKEN ROCK. STRONG TINES ARE SUBSTITUTED FOR THE PLATE-SIDED BUCKET

Taking the various classes as a whole, the grab is an excellent implement, but it has limitations. It cannot be employed effectively and expeditiously over large areas, neither can it be counted upon to leave an even surface. The tendency is, rather, to pit the ground with a series of hollows or depressions,

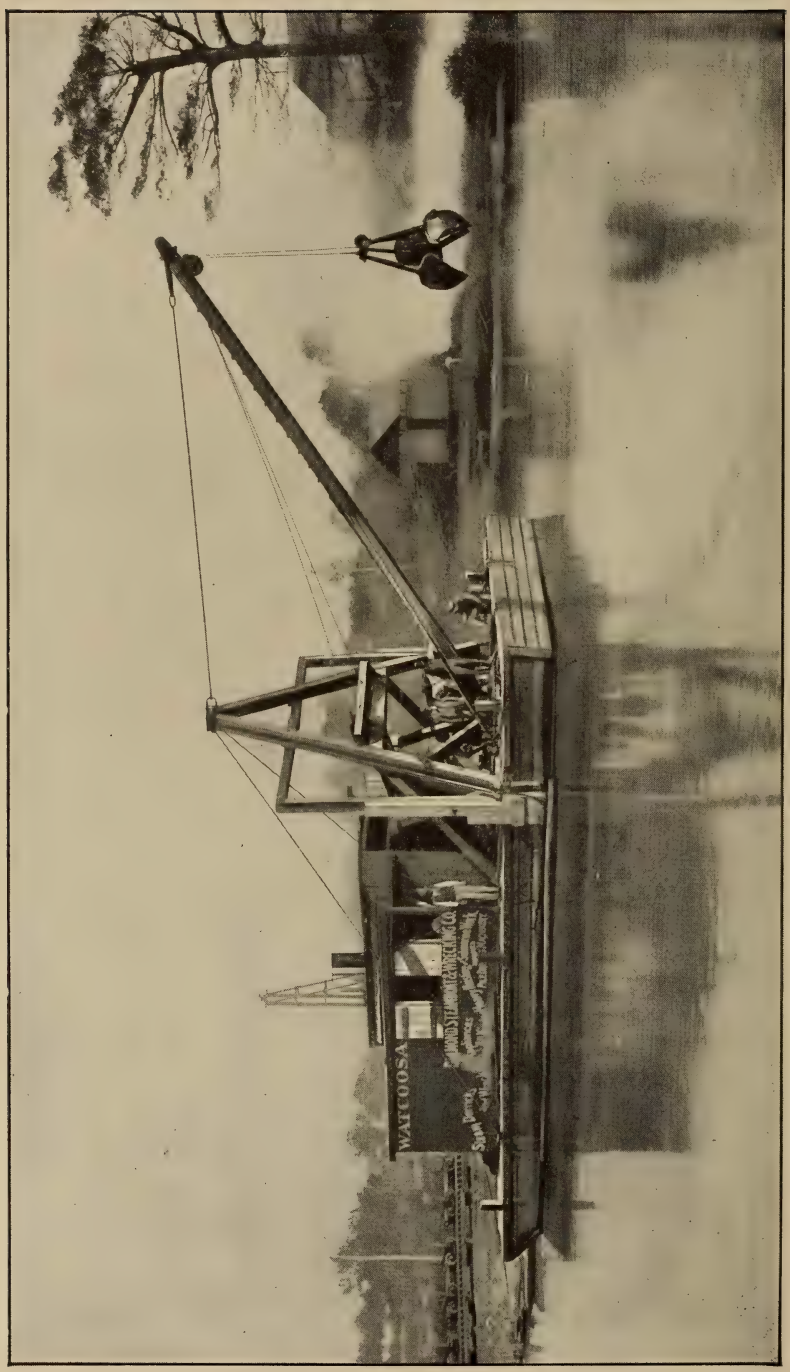


FIG. 4.—AN "ORANGE-PEEL" GRAB DREDGER, BUILT BY THE HAYWARD COMPANY, NEW YORK

leaving intermediate peaks and ridges. In confined and awkward situations, however, such as occur in narrow waterways and docks, where other appliances are hampered in their movements, if not found altogether impracticable, the grab gives its fullest measure of usefulness; it is, therefore, largely in evidence for maintenance work at ports and harbours.

As regards material, its best performances are made with mud, sand, and soft earth, of which something like 50 tons per hour can be raised under favourable circumstances by a bucket with a capacity of 1 cubic yard. But in clay and indurated earth, scarcely more than half this quantity could be raised, and in very stiff material the amount would be much less.

Open Closed

FIG. 5.—A HAYWARD "ORANGE-PEEL" BUCKET

One important use of the grab dredger is to clear away from subaqueous sites the rock and masonry débris produced by blasting operations. For this purpose, instead of the ordinary plate-sided buckets, those having strong tines or interlocking teeth are used. Not infrequently also, plate buckets themselves are fitted with short outside tines in such a way as to give them more digging power without interfering with their capacity for holding wet material.

Turning, now, to an entirely different principle of dredging, we will consider an apparatus that has proved itself to be unquestionably one of the most remarkable contrivances ever perfected for the removal of subaqueous material, both in regard to the vast extent of its output and the low cost of its operations. The results, in fact, that have been achieved by the hydraulic or suction dredger during the comparatively short period of its development may legitimately be described as marvellous. It is, to some extent, a special machine. There are, naturally, conditions and circumstances to which it is not applicable, but there are others for which it is peculiarly adapted. It would be useless to expect it to dredge hard rock or to lift massive boulders. Such intractable material lies appropriately within the province of digging dredgers. But where the ground is soft and incohesive, and even in many cases where it is firm and tenacious, the efficacy of the suction dredger has been demonstrated beyond question.

Also, in exposed situations, such as prevail along a seacoast, it possesses a marked advantage over apparatus of other types, the working of which is often materially interfered with by the motion of the waves. Equipped with telescopic pipes and flexible joints, it can ad-

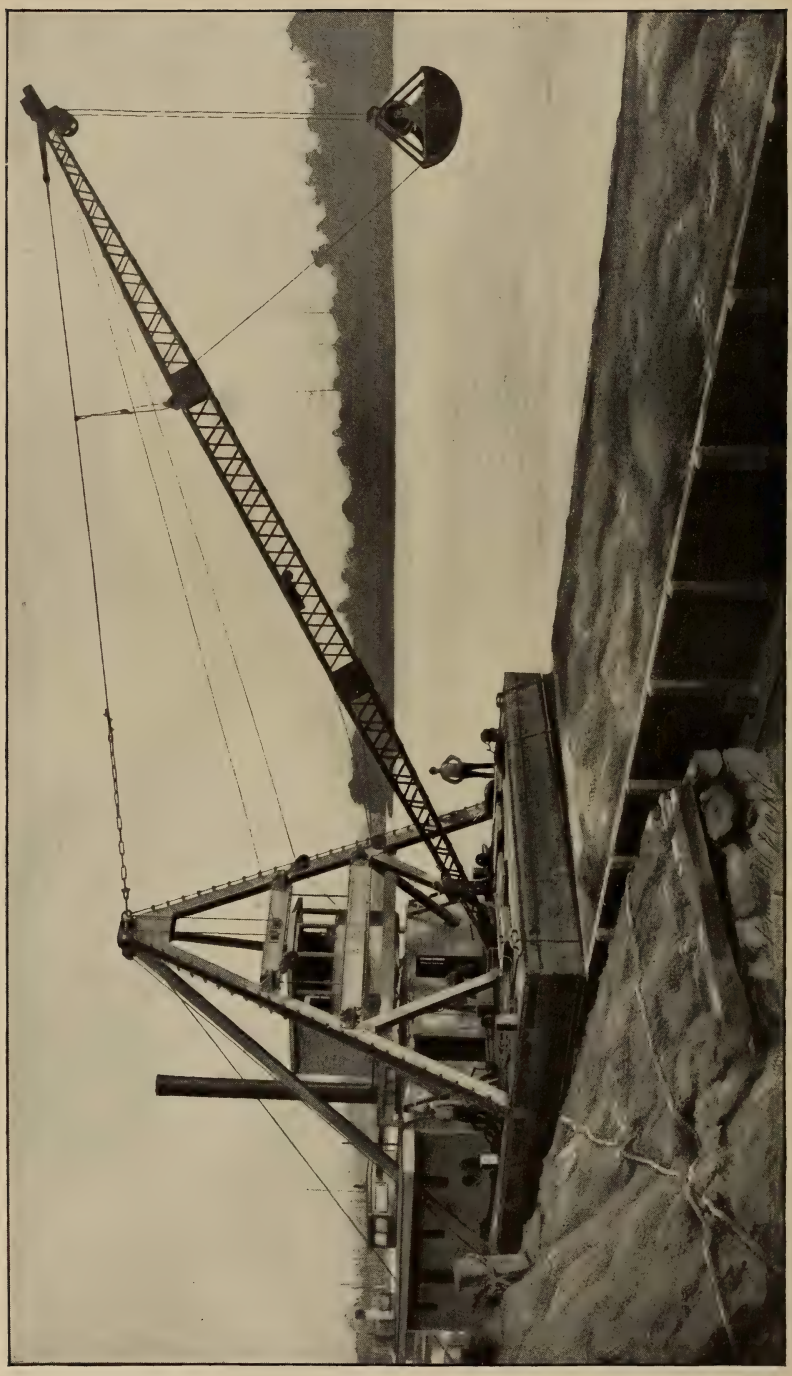


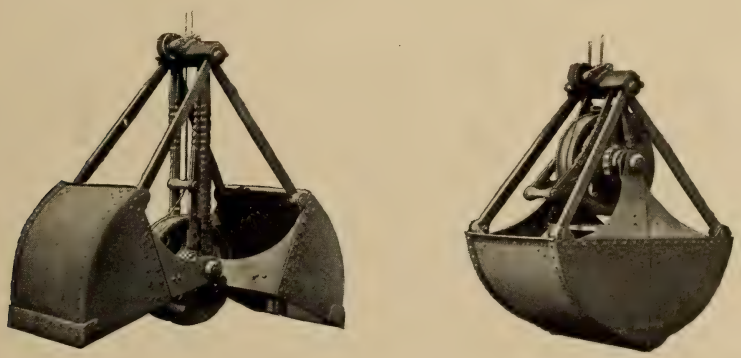
FIG. 6.—A CLAM-SHELL BUCKET DREDGER, BUILT BY THE HAYWARD COMPANY, NEW YORK

just itself to the rise and fall of the sea and be quite independent of variations in level, either momentary or prolonged.

The suction dredger consists essentially of a continuous pipe or tube, through which, by means of suitable machinery, material is sucked up and discharged either into a hopper forming part of the vessel itself, or into a scow arranged alongside, or through a chute or tube on to an adjacent bank or shore. In the case of sand, no preliminary treatment is necessary, the light, granular nature of the material rendering it particularly suitable for raising by suction. So readily does it incorporate with the upward flow, that the difficulty is rather to secure its deposition again and to avoid a very large percentage of it being carried away in suspension with the water escaping over the sides of the hopper or scow. Indeed, until quite recently the employment of the suction dredger was confined entirely to the removal of sandbanks, and it has been not infrequently designated the "sand-pump dredger."

Experiments have demonstrated, however, that by the aid of cutters and similar devices, marl and stiff clay and adhesive material generally may be separated and dissected to a degree compatible with removal by pumping. Furthermore, it has been found that argillaceous earths exert far less frictional resistance to hydraulic transportation through pipes, and so produce less wear and tear, while certain unctuous clays may even be said to contribute to the facility of their own removal. This is no negligible consideration.

The cutters employed are, generally speaking, cylindrical, with straight or spiral blades mounted concentrically around the nozzle of the suction pipe. They may be secured to the suction pipe nozzle and a rotary motion imparted to them together, or the cutter shaft may be journalled in a bearing specially provided in the end of the suction pipe, which is then made stationary. Thus, for instance, in the dredger "Lindon W. Bates," built in 1900 for the Calcutta Port Commission by Mr. Bates himself, the designer and inventor, the flanges of the knives were riveted to two conical rings by means of countersunk rivets, and the rings secured respectively to a conical disc and to a flange on the outermost length of the suction pipe. The conical rings were made identical in every respect, so that the cutter could be reversed when one end of it was worn. The conical disc and the length of suction pipe were se-



Open Closed

FIG. 7.—A HAYWARD CLAM-SHELL BUCKET

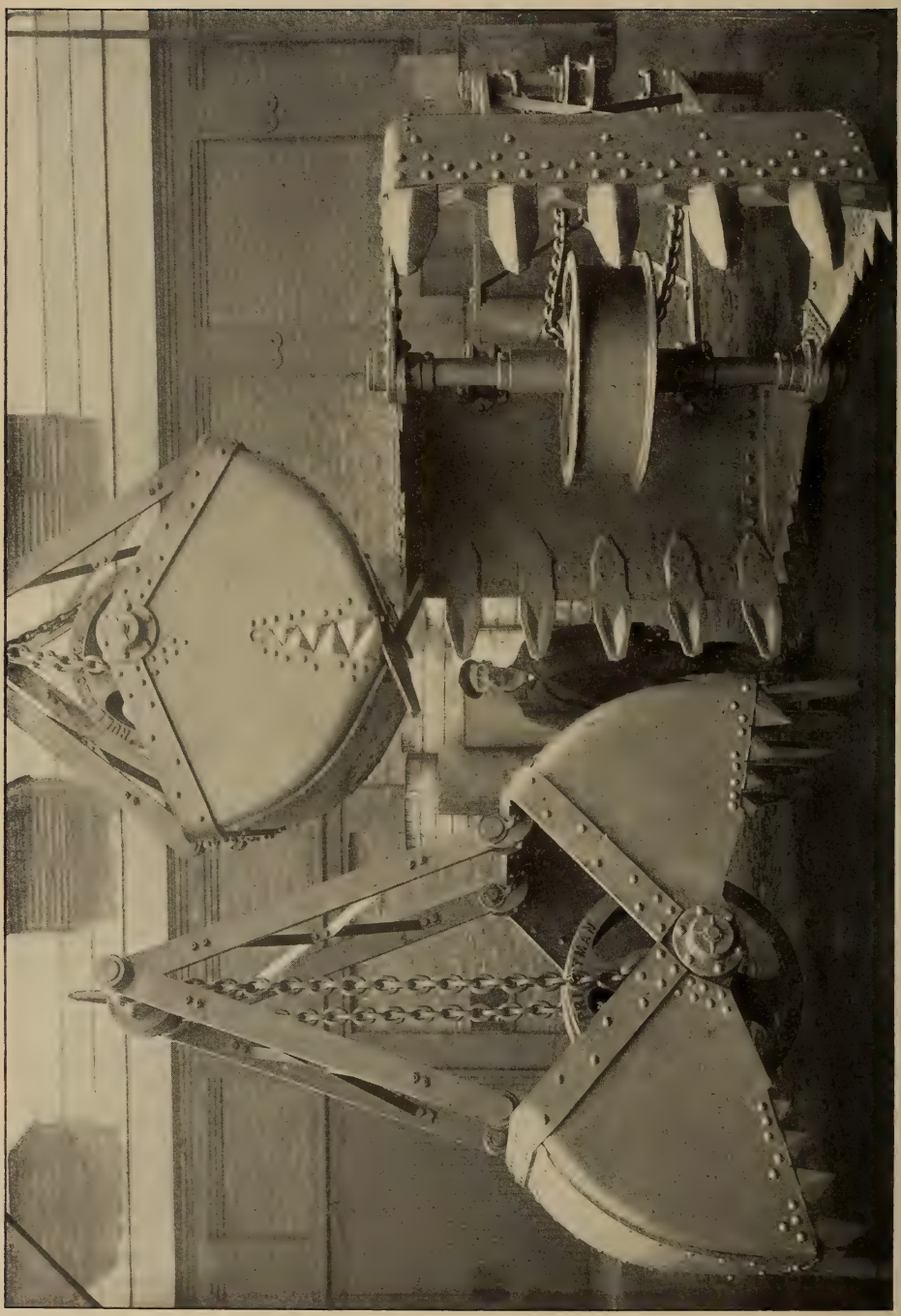


FIG. 8.—THE PRIESTMAN GRAB, MADE BY MESSRS. PRIESTMAN BROS., LTD., LONDON

FIG. 9.—TWIN SCREW DOUBLE-SUCTION PIPE DREDGER "PIONEER," BUILT FOR AUSTRALIAN GOVERNMENT SERVICE BY MESSRS. FERGUSON BROTHERS, PORT GLASGOW. DREDGING CAPACITY, 600 TONS PER HOUR. HOPPER CAPACITY, 450 TONS

cured, in turn, to a shaft to which a rotary motion was given, and with which they revolved. The bearing, made in three pieces with liners between the flanges to allow for wear and provided with lubrication by water under pressure, was set centrally to the whole. The arrangement is shown in Fig. 15.

A cutter of the second type, made by Mr. Bates, has been used by large dredgers at work on the river Volga. In this case the lower flange of the cutter casting was secured to a cone keyed on the shaft which revolved in the axial line of the suction pipe. The upper flange of the cutter was centred on a flange of the suction pipe, and the cutter was reversible as in the former instance.

The efficiency of a suction dredger dealing with a material requiring disintegration, depends to a very large extent upon the design of the cutter, the shape of the knives, and their setting relatively to one another and to the suction nozzle. Many of the early experimental forms were far from successful in their attempts to remove plastic material. The blades became clogged, and a very small proportion of solid matter found its way into the discharge pipe. The results in some cases were extremely discouraging. The writer witnessed a number of trials in which no apparent impression was made, the output being mainly or merely water. Mr. Apjohn relates a similar experience in a paper read before a recent engineering conference, and states that even after two successive modifications in the design of the cutter, the quantity turned out per hour was never more than 60 per cent. of that contracted for.

Substantial improvements have since been effected in various directions, and it is now claimed that a suction cutter dredger is capable of dealing effectively and economically with the most tenacious substances. Remarkable results have certainly been achieved in the blue clay of the bed of the river St. Lawrence, where the dredger "J. Israel Tarte," designed by A. W. Robinson, has been at work. During the month of September, 1903, a period comprising twenty-six working days, an output

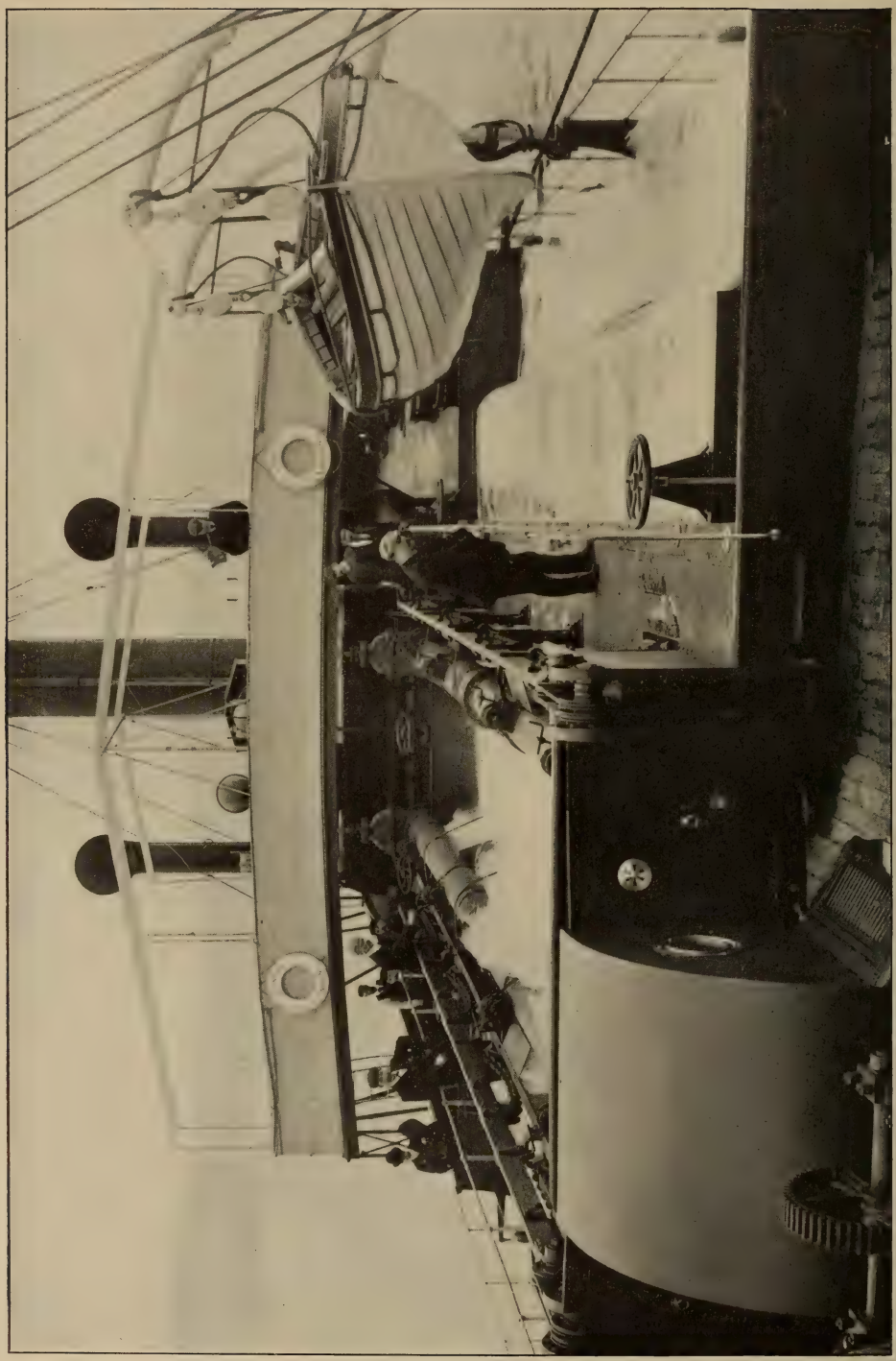


FIG. 10.—FILLING THE "PIONEER'S" HOPPER

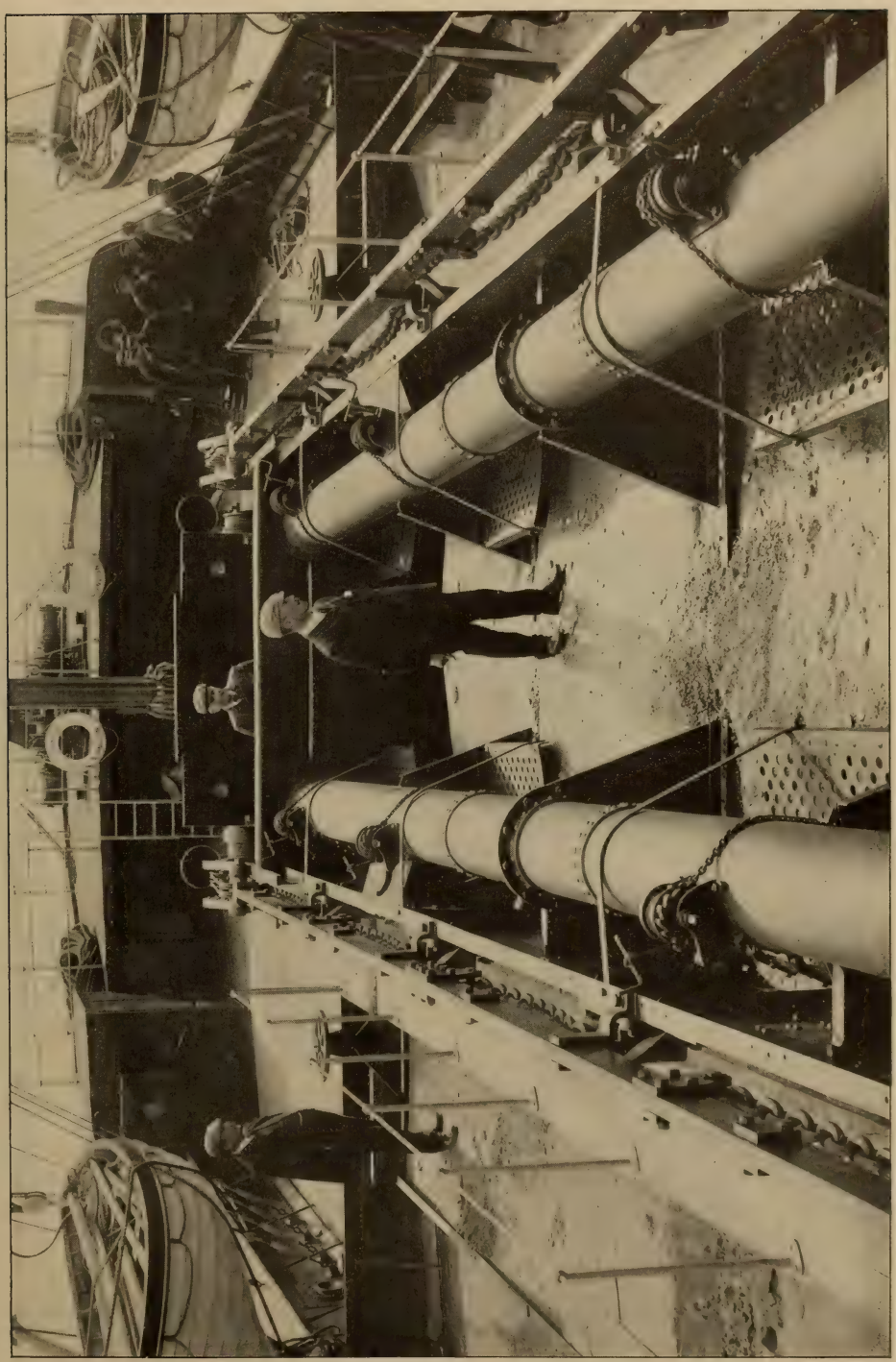


FIG. 11.—THE HOPPER FILLED

FIG. 12.—A CENTRIFUGAL PUMP DREDGER BUILT BY MESSRS. J. & H. GWYNNE, LTD., LONDON

of 757,100 cubic yards of blue clay was realized.

Loose material, such as sand, gravel, and mud, requires no mechanical assistance to render it susceptible of easy removal by pumping, and even in harbour material, where any degree of friability exists, little more than a plain eroder is necessary, and the blades may be of almost any shape. Indeed, in many cases the agitation and pressure produced by jets of water exerted in the direction of the intake pipe suffice to produce comminution. But the scope of water jets is not very great, and unless the jets are carefully designed they have a tendency to drive some of the detached material away from and beyond the zone of suctional influence. A large number of small jets is an arrangement which appears to be more effective than a few large orifices. Used in conjunction with a mechanical cutter, jets are very useful for preventing clogging of the blades. Apart from the cutter, the design of the pump has the most influence upon the efficiency of a suction dredger. The object aimed at is the elevation and transportation of the highest possible percentage of solid matter. The water lifted, except in so far as it serves for lubrication, is wasteful, or, at any rate, unremunerative. The quantity required for lubrication is not great, though it varies with the nature of the material. Some unctuous clays may not call for more than 10 per cent. of water as a minimum, but as a matter of general experience, the proportion actually pumped is much higher, commonly ranging from 30 to 60 per cent., and often exceeding the higher limit. It is difficult to fix any standard, as various materials will be encountered, and from an economical point of view it is far preferable to pump a superfluous quantity of water, rather than to risk choking and stoppage with attendant delays. It cannot be claimed

that pump dredgers are economical in the matter of power, but the simplicity, smoothness, and rapidity of their working compensate to a very large extent for this disadvantage.

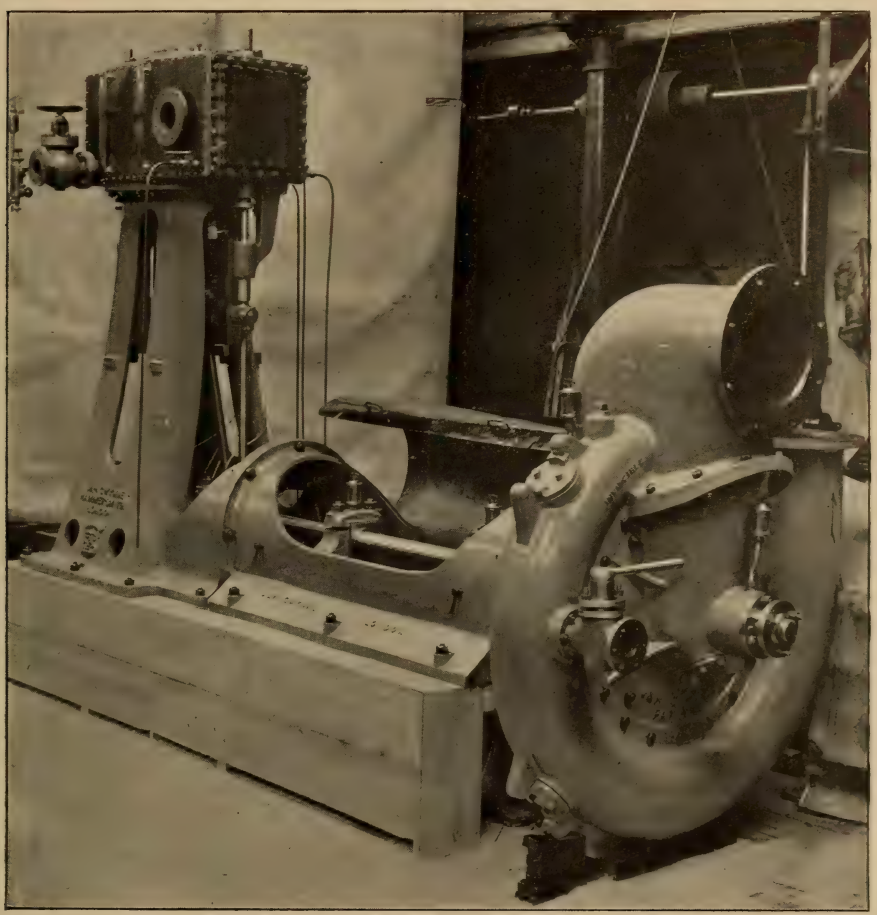


FIG. 13.—A 15-INCH COMPOUND CENTRIFUGAL DREDGER PUMPING ENGINE BUILT BY MESSRS. J. & H. GWYNNE, LTD. THIS OUTFIT WILL RAISE ABOUT 300 TONS OF SAND PER HOUR, AND WILL LIFT FROM A DEPTH OF 28 FEET, DELIVERING THE SPOIL THROUGH FLOATING PIPES TO THE SHORE WHEN REQUIRED. THE PUMP IS SPECIALLY CONSTRUCTED FOR THE WORK, AND IS LINED WITH CHILLED SIDE-PLATES, STEEL SLEEVES TO SPINDLE, ETC., THUS RENDERING IT ALMOST INDESTRUCTIBLE

Centrifugal suction pumps, which are most commonly employed, have either a single or a double inlet, and of the two, the single inlet is perhaps to be preferred.

Where there is no central diaphragm, a double inlet must inevitably lead to concussion between the two branches of the entering stream, and so destroy or nullify part of their useful momentum, whereas the larger area and less abrupt bends of a single inlet produce less interference with the flow. The absence of any necessity for balancing is a serviceable characteristic of the double inlet, but the corresponding need in the case of the single inlet may be overcome by an ordinary marine thrust bearing or by a modification in the design of the impeller

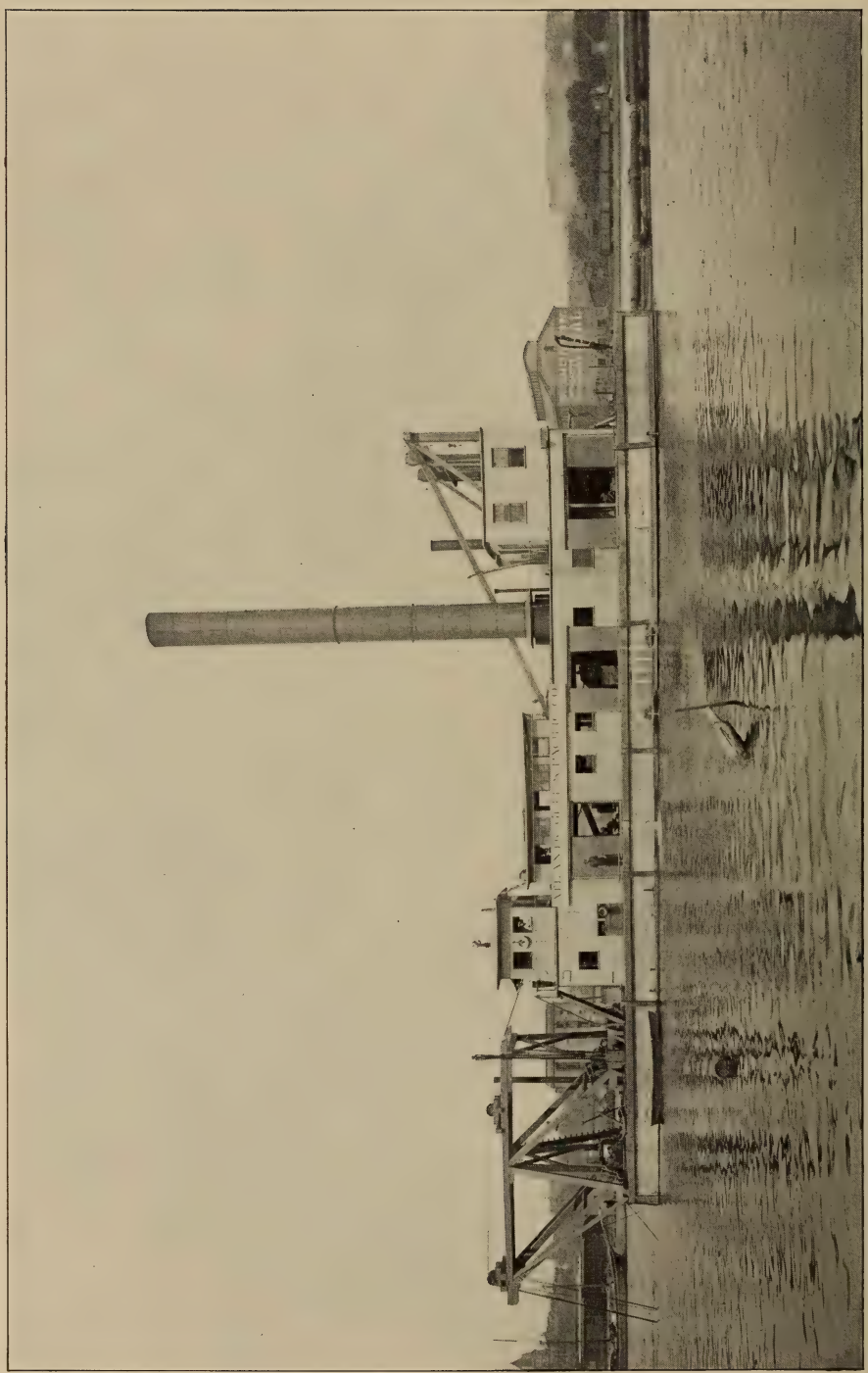


FIG 14.—A CENTRIFUGAL PUMP DREDGER OF THE ATLANTIC, GULF & PACIFIC CO., NEW YORK. THE DISCHARGE GOES THROUGH THE PONTOON-SUPPORTED PIPE LINE AT THE RIGHT TO AN ADJACENT SPOIL BANK

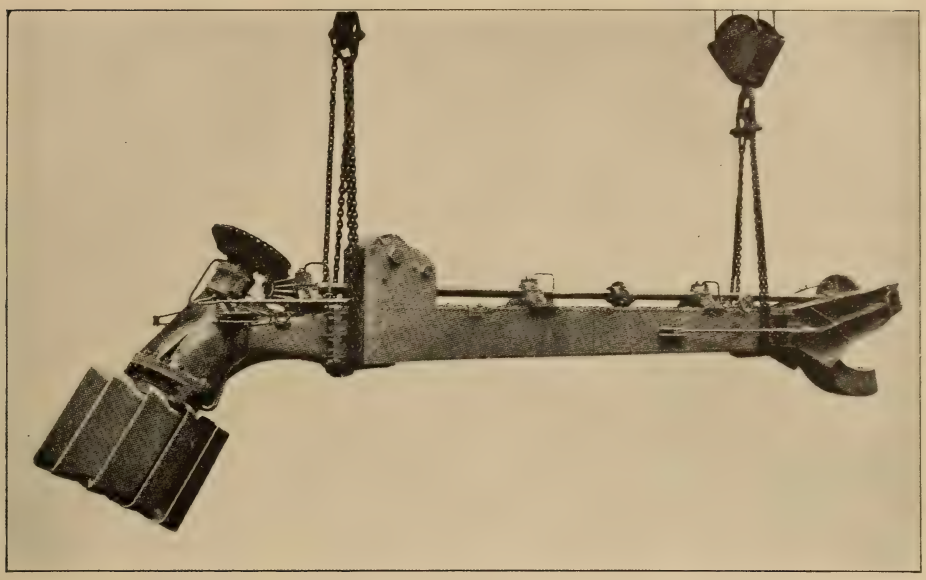


FIG. 15.—A SUCTION PIPE AND ROTARY CUTTER MADE BY LINDON W. BATES, NEW YORK

whereby the end thrust is taken by the pump casing itself. The passages are an important feature, and they should be larger than the intake pipe, in order to avoid or lessen the risk of some bulky object becoming jammed in the interior.

In connection with this it is both curious and instructive to glance over a record of strange objects found from time to time within the pump casings of working suction dredgers. Large stones, pieces of concrete, corroded and shapeless lumps of metal, lengths of chain, iron bolts, hooks, and shackles,—such are a few of the more commonplace articles picked up from the depths. The writer has seen an almost rectangular piece of sandstone measuring, roughly, 18 inches by 13 inches by 9 inches, and weighing something like 150 pounds, which was recently removed from the pump of a dredger.

Many other, and even more remarkable, instances might be adduced to show the extraordinary nature of a hydraulic dredger's experience. In itself, however, this example is sufficient indication of the wear and tear in suction pumps and pipes, and proves the eminent desirability of spaciousness in the pump and of strength in its casing. The casing is often lined at the centre with renewable steel plating, secured in place by set screws passing through the pump cheeks and into rings cast on the back of the liner.

It has been mentioned that suction dredgers discharge their material either into hoppers for conveyance elsewhere, or directly on to an adjacent bank or shore by means of a chute or floating tube. The chute is applicable only to short distances, and is generally used in connection with high banks. When the floating tube is employed, the length may be considerable.

The design of the pipe line greatly influences the efficiency of the system. As a rule, the discharge pipe consists of a number of lengths of steel piping, circular or elliptical in section, supported by floating pontoons and united by flexible connections either in the form of leather or rubber hose with steel pins and clasps, or by universal joints made on the principle of the ball and

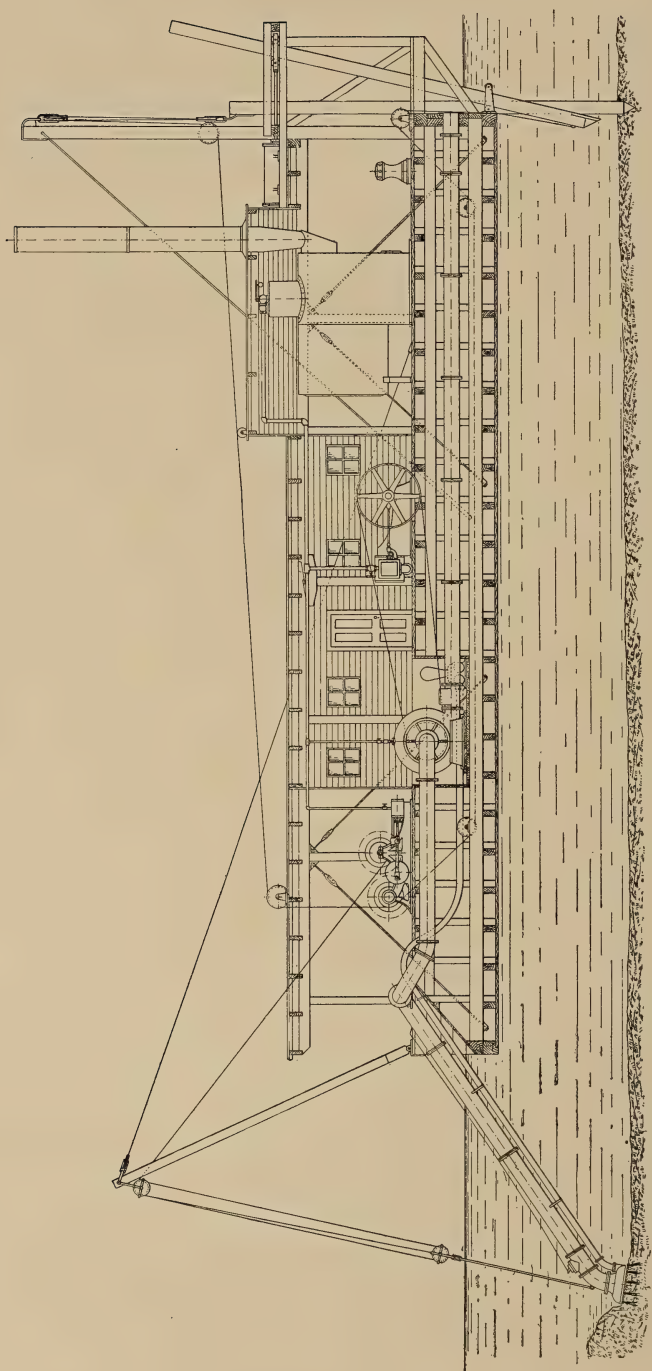


FIG. 16.—ELEVATION AND SECTION OF A SUCTION DREDGER BUILT BY THE MORRIS MACHINE WORKS, BALDWINSVILLE, NEW YORK

socket joint. This latter method is the latest and more satisfactory arrangement, and as adopted in a typical case, the ball and socket, which were of steel, were attached respectively to the adjoining ends of two

Tarte," already alluded to, the discharge pipe is a circular conduit, 36 inches in diameter, constructed in 100-foot lengths and flanked on each side by a water-tight cylindrical pontoon of 42 inches diameter. A new

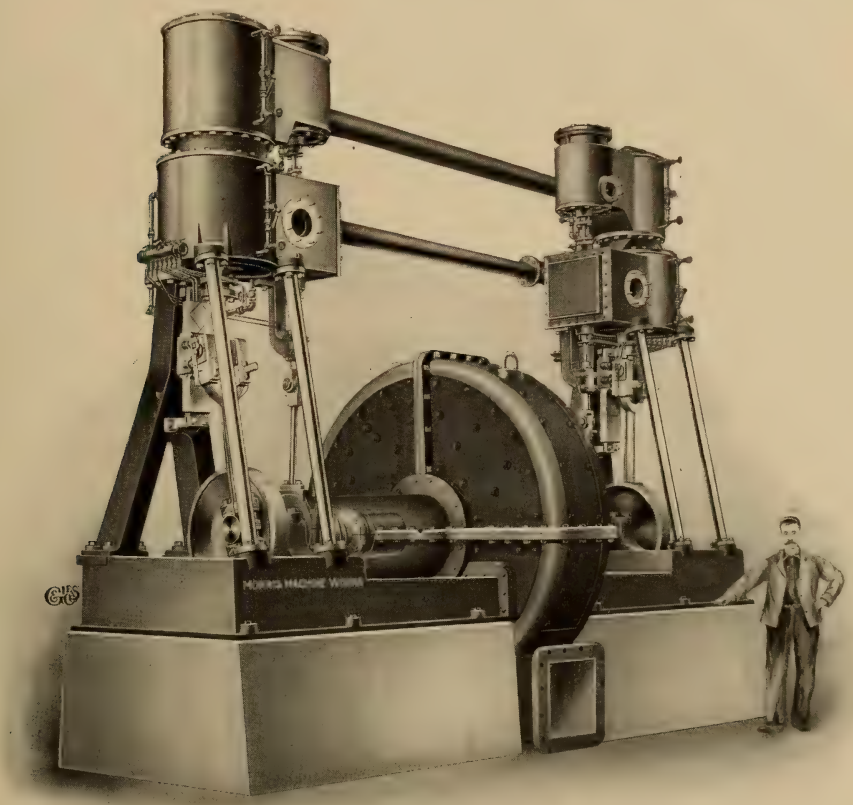


FIG. 17.—A 20-INCH STEEL-LINED DREDGING PUMP, DIRECT CONNECTED TO A 4-CYLINDER TRIPLE EXPANSION ENGINE, BUILT BY THE MORRIS MACHINE WORKS, BALDWINSVILLE, NEW YORK

pontoons, or rather of frames attached to them, the pipe itself being made continuous by ordinary rubber sleeves.

It is not desirable to have the discharge pipe fixed in one position for any length of time. Greater scour and wear occur along its lower surface, and the turning of the pipe leads, therefore, to greater uniformity of abrasion, and so increases the serviceable life of the pipe.

In the Canadian dredger "J. Israel

dredger, the "B. M. Harrod," now being built in connection with operations on the Mississippi River, is to have a discharge pipe of the same diameter and sectional length, but is to be supported on ten circular pontoons, each 28 feet in diameter, 5 feet 3 inches deep at the center, and 2 feet 3 inches deep at the edges. The object of this arrangement is to make the pipe line more accessible. It is difficult to couple up large pipes when they are al-

most completely immersed in water.

The work on the Mississippi River has now been carried on for thirteen years, and there are eight vessels in the fleet of dredgers working there. Various types of the hydraulic dredge have been experimented with, and the observations and tests have led to a number of valuable conclusions in regard to the efficiency of suction dredgers engaged in dredging sand under various conditions. These results have been published in the reports of the Mississippi River Commission, so that it is not necessary to refer particularly to them here. One or two of them, however, are of sufficient general interest to deserve mention.

In the first place, it was ascertained that the most efficient peripheral speed for a centrifugal sand pump was about 50 feet per second, and that while an increased output could be obtained by a greater number of revolutions, it was at the expense of mechanical efficiency. The double intake at the pump casing was found unobjectionable, in this respect controverting to some extent the opinion previously held. Further, no decided difference was discovered in the different forms of suction heads in use. This is decidedly contrary to the experience gained with suction dredgers on the

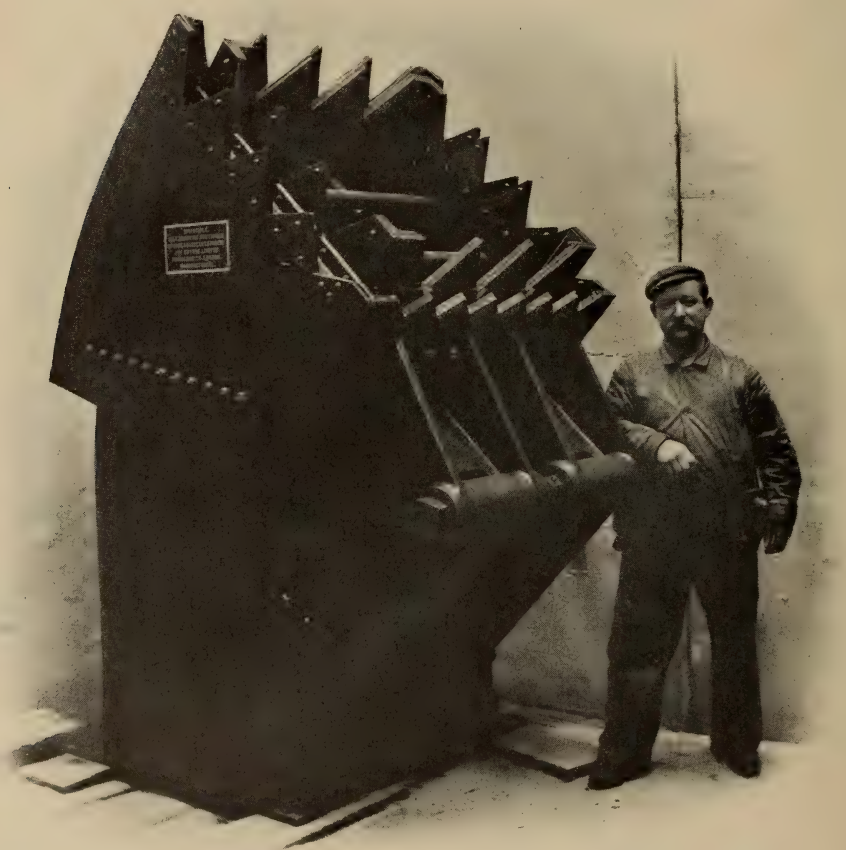


FIG. 18.—ADJUSTABLE MOUTHPIECE OF A GWYNNE CENTRIFUGAL SUCTION DREDGER. WITH THIS APPLIANCE THE PERCENTAGE OF SAND DELIVERED BY A PUMP IS CONSIDERABLY ENHANCED

FIG. 19.—BOULDERS RAISED FROM THE BED OF THE RIVER THAMES AT LONDON BY AN 8-INCH GWYNNE CENTRIFUGAL PUMP DREDGER

Mersey River, in England, where it has been found that the area and form of the nozzle materially influence the percentage of sand raised.

These and other results show that unanimity of opinion has not yet been attained on many important points connected with the design of hydraulic dredgers. There is ample scope for further data and for further development. The machine is still in the experimental stage, and valuable as is the work already done, there are great possibilities still before it. A. W. Robinson, in a paper read at the International Engineering Congress in October, 1904, mentioned a number of directions in which progress was desirable in the design of hydraulic dredgers.

"Further improvements are needed in greater perfection of detail, a wider range of mechanical cutting apparatus, a better method of flexible pipe joint than the rubber sleeve or ball and socket, and a motor for the pump which will run faster than the triple expansion engine and permit smaller and better pumps to be used. Such a motor will be developed from the steam turbine, although the present state of the art does not admit of the combination, as turbines are not yet built of moderate power and slow speed adapted for direct connection to dredging pumps. Electric motors will seldom apply, but the possibilities of the oil engine, as doing away with boiler and accessories, should not be overlooked."

These indications of the probable lines of future development must serve as a termination to this necessarily brief and restricted consideration of the hydraulic or suction dredger and its compeers.

MACHINE SHOP ROOFS

By D. F. Nisbet

IN an article under the above caption in the August number of this magazine, Prof. John E. Sweet states that, "primarily roofs are for the purpose of protecting buildings and their occupants from the elements, and in that, roofs for machine shops do not differ from roofs of other buildings; but for the machine shop, the roof may help to do many things besides, and while these things may call for a modification of the regulation style, and even in some cases add to the cost, the gain will more than justify the modification. Assume, for example, a shop of the prevailing type,—a central bay for the traveling cranes, and wings and galleries on each side. The roof over the central bay has no function to perform, nor can it be made to serve any useful purpose, except to ward off the elements,—and no question can arise except,—Is the usual form of construction the best and most economical?"

It is true that the roof, not only for the machine shop, but for many other manufacturing buildings, may be made to serve a purpose other than simply sheltering the interior and its occupants; but the fact remains that a large portion of those for whom such buildings are designed and erected consider them only as shelters, and do not properly evaluate many features of building construction, which, if properly adopted, would soon pay for themselves.

In erecting a building for a machine shop, or in fact any building intended for manufacturing purpose, it is quite usual to simply adopt some prevailing type of what may be termed industrial architecture, regardless of the fact that it may be ill-suited for the particular line of manufacture for which it is intended. For instance, what may be termed the movement of materials, is frequently given only perfunctory consideration, whereas it should be carefully studied with a view to reducing the number of handlings and operations to a minimum.

Other instances might be given, all of which would tend to indicate

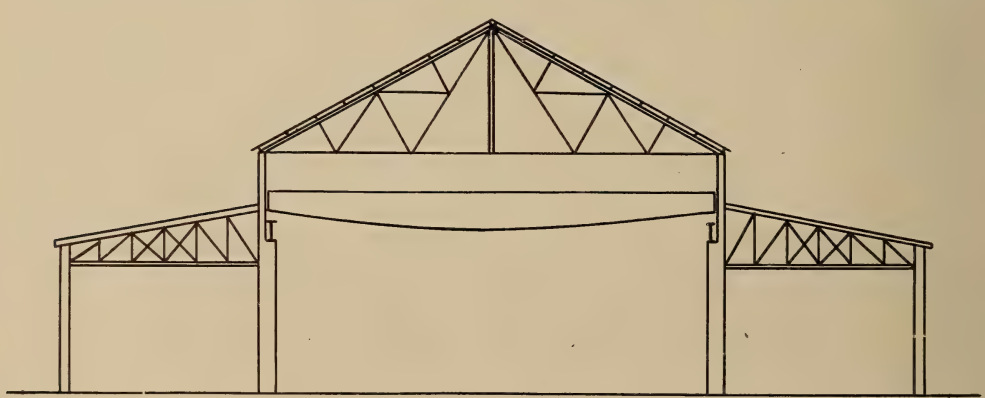


FIG. 1 —CROSS-SECTION OF A RAILWAY REPAIR SHOP, SHOWING USUAL TYPE OF ROOF CONSTRUCTION

that buildings for manufacturing purpose should be laid out from an engineering viewpoint rather than an architectural one; and the building should be as carefully designed for its intended use as a machine should be designed for a particular purpose.

Of the various problems arising in the design of buildings, the lighting and ventilation present more difficulties in buildings of the type assumed by Professor Sweet as an example, than almost any other. This applies particularly to the central portion. It will be seen from an inspection of Fig. 1, which represents a cross section of a railway repair shop, and shows the usual construction of buildings of that type.

In this construction, all the strictures applied by Professor Sweet obtain with full force. All the light procured in the central portion of the shop is limited to that which is obtained through the media of the small windows above the side bays,—and these are frequently, in buildings of this type, partially obstructed by crane girders,—and through the end windows; but as this building is over 500 feet long, the end windows have little influence on the lighting as a whole. The side bays depend on side windows, and the lighting in these portions is fairly satisfactory. In the central portion, however, the lighting is of the dim, but not religious, variety.

It is the purpose of this article to show one method of utilizing the roof for purposes other than merely shelter, and other than those contemplated by Professor Sweet, at the same time taking issue with the statement that the roof of the central bay, in the example cited, cannot be made to serve any useful function other than warding off the elements, and incidentally answering the query in the final sentence of the excerpt in the negative.

Had the building, or at least the

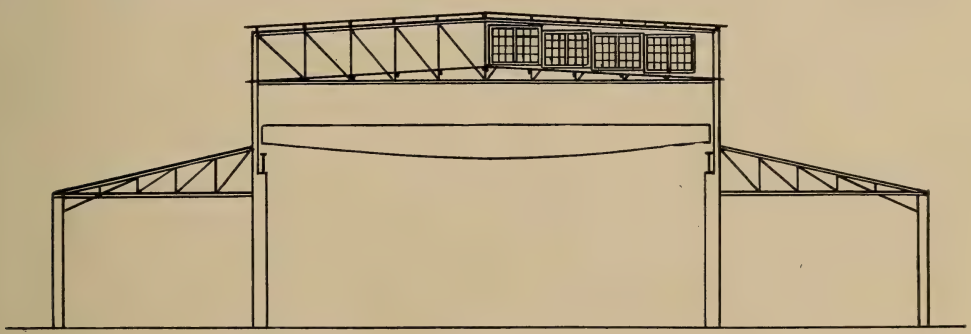


FIG. 2.—AN IMPROVED FORM OF SHOP ROOF

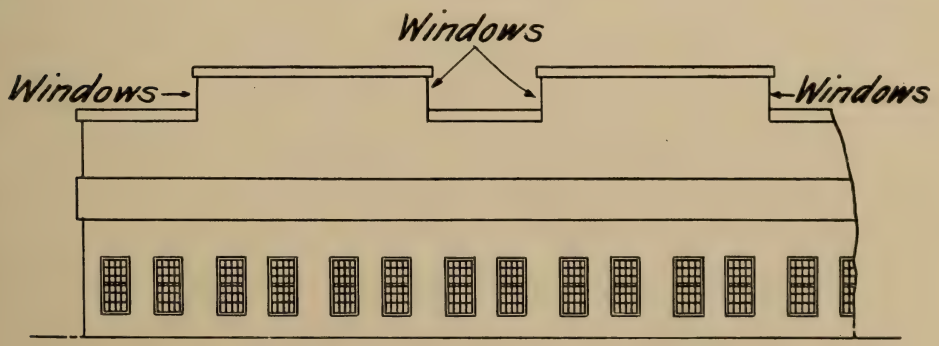


FIG. 3.—SIDE ELEVATION SHOWING ARRANGEMENT OF THE WINDOWS

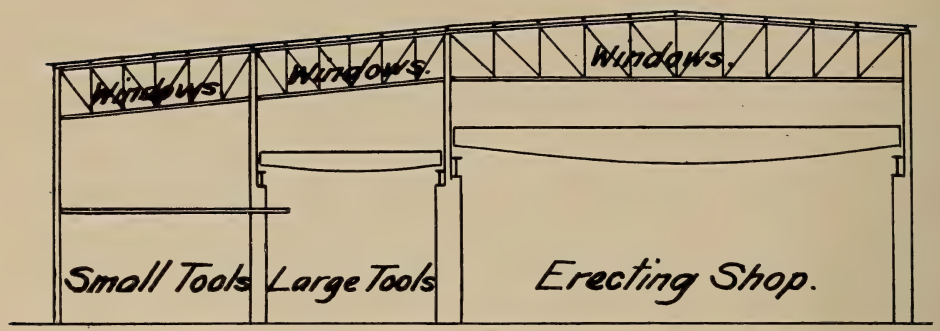


FIG. 4.—A MODIFICATION OF THE DESIGN SHOWN IN FIG. 2

central or main portion, been constructed with a roof such as is shown in Figs. 2 and 3, the lighting of that portion would have been all that could be desired. The characteristic feature of this type of roof lies in the disposition of the purlins. On one or more bays the purlins are placed on the top chord of the roof trusses, and in the next bay they are placed on the lower chord or on supporting clips attached to the vertical members of the trusses, making alternately a high and a low roof, and utilizing the vertical faces of the high portions for the insertion of rows of windows extending across the building. This construction is known as the Aiken type of roof, and serves all the purposes for which a roof is intended, as well as furnishing abundant light and means for thorough ventilation. This construction is patented.

Fig. 4 shows a modification of Fig. 2, using the same type of roof and occupying the same ground area; but, in the writer's opinion, it would be much more satisfactory, as it admits of an easier distribution of work and easier superintendence.

Concerning the spacing of columns and trusses in machine shops and other manufacturing buildings, each case has usually to be worked out in conformity with such conditions as are imposed by the particular use for which the building is intended, no mathematical formula being applicable to this matter.

It may be stated, however, as a general rule, that in buildings carrying traveling cranes, it is the more economical to space the columns from 16 to 24 feet apart, as the columns carrying the crane girders will be practically of the same section and weight, irrespective of their distance apart, the only difference in their loading being in the weights of the girders themselves, which is small compared with the weight of the crane and its load.

There is another objection that frequently obtains in designing trusses for light loads, which will apply to trusses closely spaced. That is the fact that in many instances it will be found that the sections indicated by the stresses imposed by the load are too small to permit of making satisfactory connection with them; consequently a larger section must be used, and in a building with many trusses this entails considerable increase in the amount of material used.

A COUNTRY ESTATE WATER SUPPLY SYSTEM

WITH PRESSURE-TANK INSTALLATION

By William Paul Gerhard, C. E.

FIG. I.—THE PUMP HOUSE

THE summer home of Hon. Thos. C. Platt, U. S. Senator, located at Highland Mills, N. Y., was recently fitted up by the writer with a modern system of water supply, furnishing an abundant quantity of water not only for the needs of the mansion, stable, cottage and farm buildings, but also for lawn sprinkling, and last, but not least, for fire protection.

A preliminary examination of the estate and its surroundings disclosed three possible methods for the solution of the problem of water supply. In each of these the water was to be pumped from a lake protected from pollution by stringent State laws. The first solution of the problem, which naturally suggested itself, consisted in using a modern elevated water storage tank, erected on the grounds and supplied with water from an engine-driven pump. A windmill for pumping the water was considered to be out of the question on account of the uncertainty in that particular locality of sufficient wind pressure in summer time. The pumping plant was to be placed in a specially built house near the lake and was to consist of a triplex pump directly geared to either a gasoline or an oil engine. The tank with its supporting tower would have to be erected in immediate proximity of the residence, as the latter stands upon the highest knoll found on the property. The elevation of this knoll is about 106 feet, the zero point being taken at the mean water level of the lake.

The fact that the tower would have to be placed so close to the house made this project a rather undesirable one, on account of the unsightly appearance of such a structure side by side with a handsome country residence. The tower could, of course, have been made attractive by architectural ornamentation, but this would have been quite costly. The system had the advantage of cheapness, if a plain wooden or steel tower had been used with a wooden tank, and also the advantage of absolute simplicity.

The second plan was similar to the first one as far as the construction of the pump house and the pumping apparatus were concerned. It contemplated, however, a scheme by which the unsightly tank tower was avoided. To the south of the estate, about 2000 feet distant from the house, on a neighbouring property, there is a hillside, on which, at an elevation of about 90 feet above the knoll where the house stands, an underground reservoir of brickwork could be built, if the permission to do so and the right of way to lay pipes were obtained by purchase or

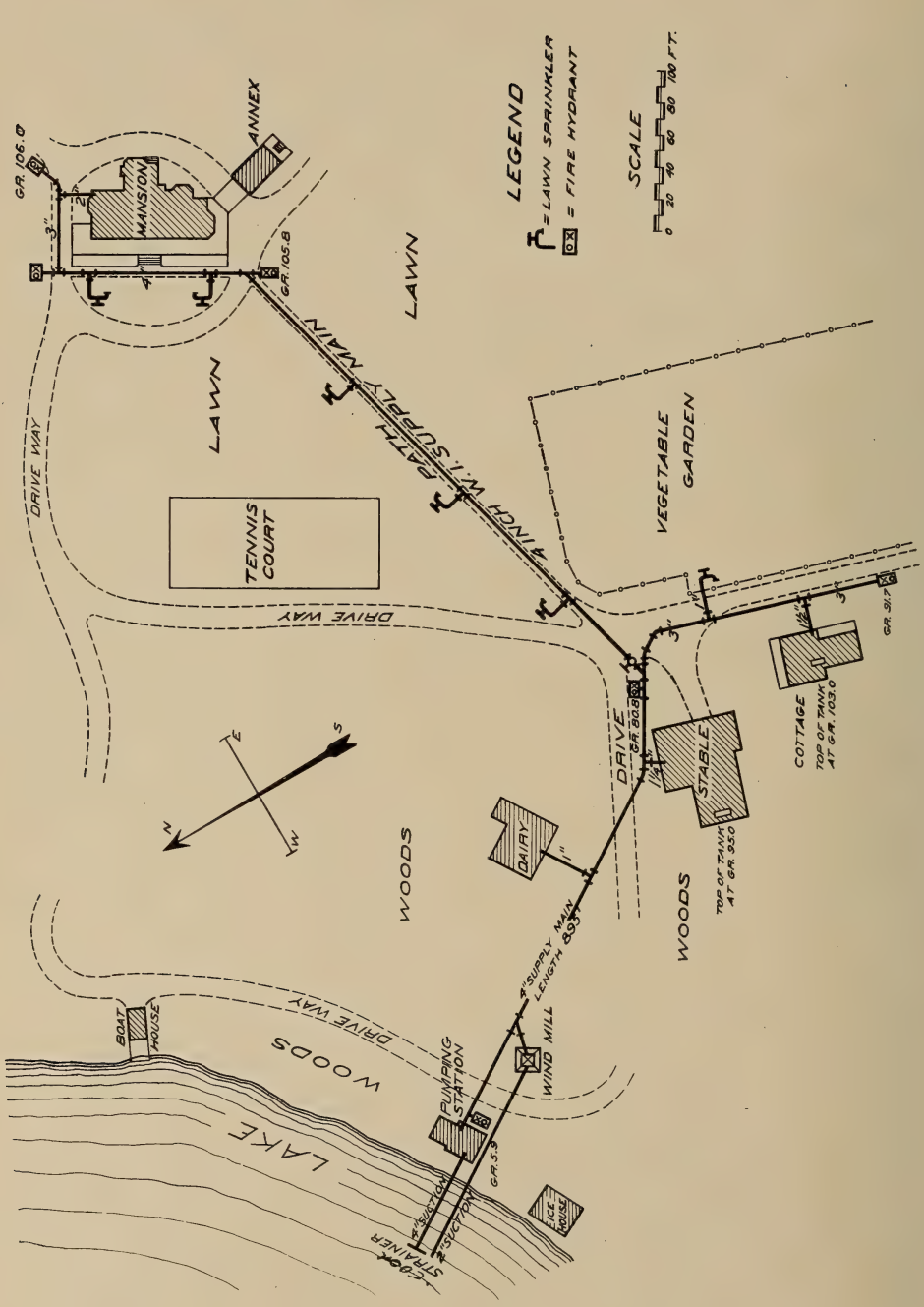


FIG. 2.—PLAN OF WATER SUPPLY FOR A COUNTRY ESTATE

other agreement. The total length of the pipe line from the lake to the reservoir and from the reservoir to the residence and other buildings was, however, in this plan so much greater that the cost of the entire system became unduly increased. For this and other reasons which need not be here mentioned, this plan was discarded.

In some respects the underground storage-tank system would have offered a satisfactory solution of the problem from an engineering point of view, for the reservoir would have acted as a settling basin for suspended matters, and its covering would have prevented the possible growth of algae. The water in the underground tank would also remain cooler than in an elevated tank.

A third plan proposed, and the one finally accepted, was the pressure-tank system, the special type chosen being that of the Acme Water Storage & Construction Company, of New York, who were also the contractors for the pumping plant. The extreme compactness of this system recommended it above the other two to the engineer and the owner. The entire mechanical portion, including the water and air storage tanks, are placed in one building, under the same roof, and are at all times accessible and so located that damage or an interruption of the pumping is avoided if only the pumping station is kept warm during the winter months. Moreover, this system enables the operator in charge to force the water out under any desired pressure,—a distinct advantage over the elevated storage tank and the reservoir system, especially in case of fire, when it might become desirable to increase the water pressure over that ordinarily carried in the mains.

Compared with the first system, this one eliminates the objectionable tank and tower, and compared with the second plan, it provides for the storage of water on the owner's grounds and also does not unduly increase the length of the pipe lines required for distribution. Moreover, a feature of the second system, namely, the entire exclusion of light from the stored water, is likewise embodied in the third plan. One other advantage is gained over both discarded plans, namely, that the water comes into intimate contact with air under 75 pounds of pressure, whereby some of the organic impurities are oxidized.

In such a system two air-tight steel or iron tanks must be provided, one a water-pressure tank, the other an air-pressure tank. The water is pumped into the bottom of the former, while the air is forced, by means of an air compressor, into the top of the latter tank. There is a connecting pipe between the tops of the two tanks, through which the air pressure in the air tank acts upon the water in the water tank and thus forces the water out of the bottom of the latter through the discharge main to the delivery outlets. This explains in a general way the principle of the pressure-tank system of water supply.

The pumping station as constructed, containing the pumping machinery and the tanks, is shown in Fig. 1, the photograph having been taken from the shore. It is a one-story brick structure, with shingled hip roof, and consists of a main part, 20 by 12 feet, containing the engine, pump, and compressor, and a wing, 15 by 15 feet, containing the two tanks. Fig. 3 will further explain this arrangement. The house is excavated to a depth of about 5 feet, a staircase leading from the entrance door to the cemented floor of the pump room. This partly underground location of the house aids in keeping it fairly warm during spring and fall weather. For winter use the building is fitted up with a smoke flue for a heating stove, but the probability is that the pressure-tank system will be used during the summer only. There is no reason, however, why the system cannot be operated

during the winter, for instance, in case of fire.

The machinery consists of a triplex plunger pump with a capacity of 75 gallons per minute, a gasoline engine

water tank can readily be calculated.

An air space above the water is desirable to act as a cushion, and due allowance should be made for this in determining the cubic contents of

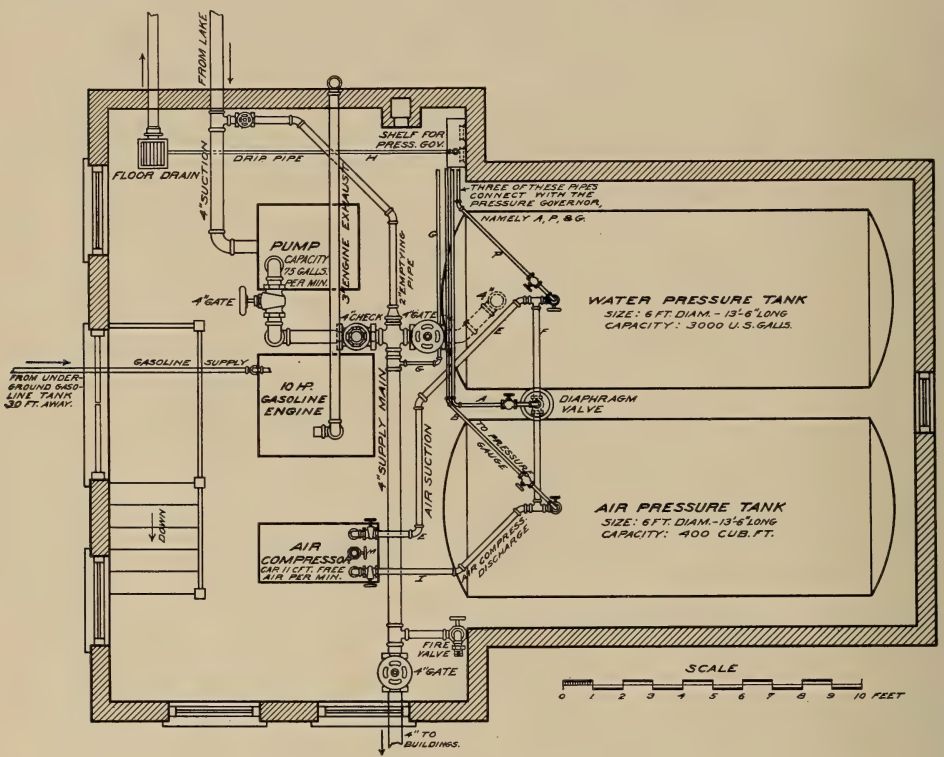


FIG. 3.—A PLAN OF THE PUMP HOUSE

of 10 horse-power, and an air compressor delivering 11 cubic feet of free air per minute.

The pump and the compressor are mounted on the same shaft by means of friction clutches, not shown in the sectional diagram, Fig. 4, but illustrated in Fig. 5. They enable the operator to run both machines at the same time, or either one at will.

The capacity of the water tank depends primarily upon the desired amount of storage and upon the frequency of pumping. Knowing how much water is going to be used per day, how much may be required in case of an outbreak of fire, and at what intervals the pump is to be operated, the capacity of the

the tank. The shape and dimensions of both the air and the water tanks depend upon the shape and size of the building, but in some cases the building, if to be newly erected, can be made to conform to the required dimensions of the tanks, and this was done in the present instance.

The size of the air tank depends mainly upon the air pressure which it is intended to carry. It is desirable always to carry the same amount of air pressure on the water, no matter what the pressure may be in the air tank, and also to have just enough air stored under sufficient pressure to force all of the water out of the water tank under the given pressure. Under these conditions the water and air

will always be pumped simultaneously, the labor of operating the machinery will be reduced, and another vital advantage will be gained, namely, that the air which has served to displace the water in the water tank, as the latter has gradually been emptied, and which is still under a certain pressure, will be exhausted by the air compressor and again transferred to the air tank.

The air suction pipe is marked *E* in Figs. 3 and 4, and the air discharge is marked *I*. Another opening, controlled by a valve, called the free air suction, *M*, may be used instead of *E* in case the air and water tanks do not empty simultaneously on account of some leak or other defect.

Bearing in mind now the desirability of having the air pressure equal in both tanks at the moment when the last drop of water leaves the water tank and also of having the air pressure, acting upon the water, uniform at all times, until all water is discharged, it becomes apparent that if we need x pounds pressure to deliver the water to the desired points of discharge, and if we wish to carry a maximum air pressure in the air tank of nx, that the required capacity of the air tank will be equal to $\frac{2}{n}$ times that of the water tank.

The pressure in the air tank is never less, but always greater, than that in the water tank, except at the instant when the last drop of water is being discharged from the water tank; at that moment both pressures are equal.

The apparatus designed to maintain a constant air pressure upon the water, while apparently quite complicated, is yet sufficiently simple in construction as not to get out of order easily. It is made by Messrs. Kieley & Mueller, of New York, and consists of a governor shown diagrammatically in Fig. 4, connected by one tube *G* to the discharge pipe from the water tank; by another, *P*, to the water tank above the highest water level; by a third, *H*, a drip pipe, to the floor drain; and by a fourth, *A*, which is really a continuation of the first pipe *G*, to a valve, called a diaphragm valve, also shown in Fig. 4, and placed on the air pipe *F* connecting the two tanks.

This diaphragm valve consists of a globe valve, with a disc closing against a brass seat, and fastened to a spindle surrounded by a spiral spring which tends to keep the valve open. The upper end of the spindle rests against the underside of a sheet of stiff, yet flexible composition metal, enclosed in a water-tight casing. The top of the latter is connected by the previously mentioned pipes *A* and *G* through the governor with the discharge main, thus producing a water pressure against the upper side of the composition diaphragm and through it upon the upper end of the valve stem, tending to counteract the effect of the spring and close the valve.

The governor is the controlling device of the entire plant. It consists essentially of a diaphragm valve *D* (like the previous one described, but without a spring), mounted on a lever *L*, a three-way cock *C*, a changeable counterweight *W*, a secondary lever *K* and a spindle *S*, the lower end of which is attached to the lever controlling the three-way valve, while the upper end is acted upon by the diaphragm *D* through the lever *L*. The pipe connections are explained in Fig. 4. The operation of the governor is as follows:—

As the pressure in the water tank falls, a reduction of pressure is also taking place on the under side of the composition sheet in *D*, since the air pipe *P* enters the diaphragm casing below this sheet. As soon as the lowest desirable limit, represented in pounds by the counterweight *W*, is reached, the latter pulls down levers *K* and *L* with the diaphragm *D*. This movement forces down the spindle *S*, which first closes the upper port and then opens the lower port of the three-way cock. The

port on the left always remains open. In this way the water pressure, acting through the three-way valve *C* upon the diaphragm valve on *F*, is shut off.

The release of the spring of the diaphragm valve on line *F* expels some of the water in *A*, opens the valve and allows a flow of air from the air to the water tank. As the pressure begins to rise in the former, consequently also under *D*, it gradually overcomes the downward pull of weight *W* and pushes upward the levers *K* and *L* with the spindle *S*. The latter then closes the lower port and opens the upper one; the water pressure passes from *G* through the three-way valve and through pipe *A*, forcing the diaphragm valve on pipe *F* down upon its seat, thereby stopping the flow of air from the air to the water tank.

Having thus considered the vital mechanical details, we will pass on to the application of the system to the problem described. The amount of water to be stored depended upon the number of fire streams to be supplied for a stated time, upon the domestic consumption, the number of hours it is desired to run the pump, and the cost of the tanks.

It was considered sufficient if one fire hydrant, with 50 feet of 2-inch fire hose and with 1-inch nozzle, should discharge water for 40 minutes under a sufficient pressure to carry the fire stream over the ridge of the house, with a pressure of 27 pounds at the hydrant. The fire nozzle under these conditions would discharge per minute about 75 U. S. gallons, the equivalent of the capacity of the pump, or 3000 gallons in 40 minutes. The entire daily domestic consumption was estimated to be somewhat less than the above quantity, and hence a water storage of about 3000 gallons was deemed to be sufficient. The water tank was therefore designed to be 6 feet in diameter and $13\frac{1}{2}$ feet long. The air tank was made the same size as the water tank in order to avoid an excessive air pressure, and a consequent undue increase in the thickness of the tank metal.

An air pressure in the water tank of 75 pounds was found necessary to accomplish the object sought, as stated above, while the air pressure in the air tank was to vary from 150 pounds down to 75 pounds, the latter being the pressure in both tanks when all the water has been

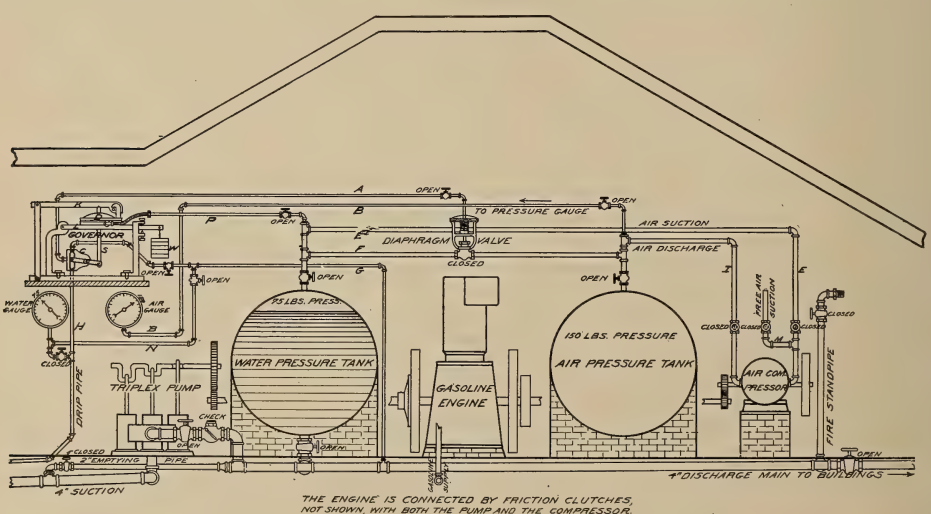


FIG. 4.—A SECTION THROUGH THE PUMP HOUSE, SHOWING THE AIR AND WATER PUMPING MACHINERY, THE WATER AND AIR TANKS, AND THE PIPE CONNECTIONS

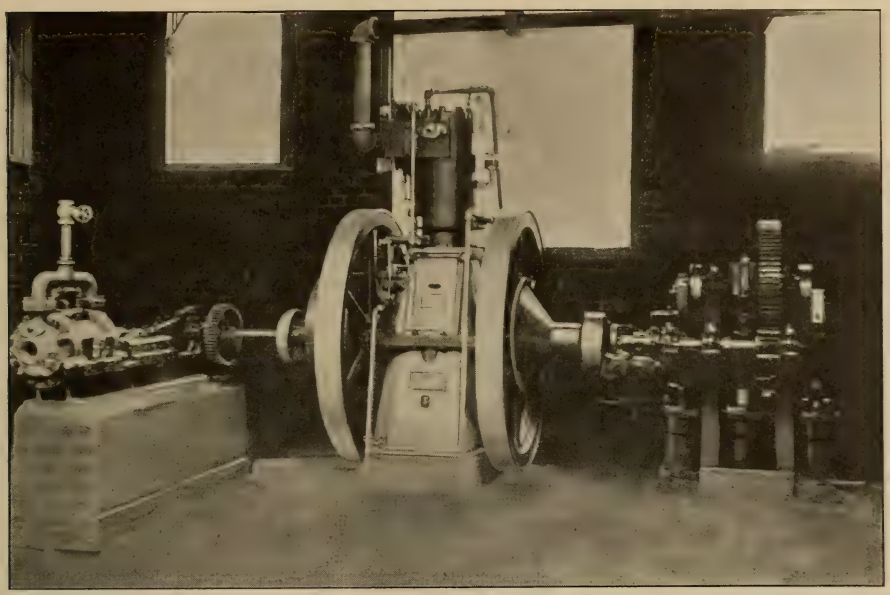


FIG. 5.—THE PUMPING MACHINERY, COMPRISING A GASOLINE ENGINE MADE BY THE NATIONAL METER CO., OF NEW YORK; A DEANE TRIPLEX PUMP; AND AN AIR COMPRESSOR BUILT BY THE NEW YORK AIR COMPRESSOR WORKS, NEW YORK

discharged from the water tank.

Three of the farm buildings, namely, the superintendent's cottage, the stable and a dairy, had to be supplied the entire year. In Fig. 2 a windmill is shown located just to the southeast of the pumping station. It is mounted on a steel tower, the pump is located in a deep pit, its suction is connected with the lake by a separate pipe, and the discharge is interconnected with the main 4-inch discharge pipe of the pressure-tank system. This windmill is intended to be ordinarily used during the winter months for the supplying of water to the farm buildings.

The entire outside piping system consists of galvanized wrought-iron pipe, of standard weight, put together with screw joints. The suction and delivery mains are each 4 inches, the branches to each fire hydrant 3 inches, those to the lawn sprinklers 1 inch, and those to the buildings vary from 2 to 1 inches, as shown in the plan, Fig. 2. The suction pipe is provided at its end in the lake with a cross-tee, and 4 feet of 4-inch pipe at each end, the ends being protected by brass strainers made by the Cook Well Company, of St. Louis, Mo. The hydrants, made by the Eddy Valve Company, of Waterford, N. Y., have 2-inch hose connections, and the lawn sprinklers are $\frac{3}{4}$-inch faucets with hose connection.

A valve was inserted in the main delivery pipe directly above the branch to the cottage (see Fig. 2) so that the mansion could be entirely shut off in the winter when the windmill is to supply the farm buildings.

The new water-pressure system was directly connected with the old plumbing pipes in the house in such a manner that the house plumbing is constantly under the pressure due to the water tank in the pumping station, the static pressure at the second floor fixtures being about 21 pounds. Whereas formerly these fixtures had a very sluggish supply from the attic tank directly over them, they now furnish a good stream and an abundant supply. The use of the former house tank was entirely abandoned.

The plumbing system of the stable and the cottage required a slightly different arrangement, and for the winter months, when the windmill is running, these fixtures are supplied from attic storage tanks; but the connections here were so made that during the summer the plumbing is also under direct pressure from the pressure tank.

The actual operating expenses of the new plant will be as follows:—

To run the engine, pump, and air compressor for one hour, required about 1¼ gallons of gasoline costing about 12 cents per gallon. The fuel necessary to run the machinery therefore costs about ¼-cent per minute, and as the pump delivers 75 gallons per minute, it follows that 300 gallons cost 1 cent to pump. If 3000 gallons of water are consumed, the daily operating expense, not including slight attendance and cost for oiling the machinery, is therefore about 10 cents, surely a very reasonable expense for an efficient water-supply system.

INDUSTRIAL TRANSPORTATION

By H. S. Knowlton

ONE of the most interesting problems in connection with the development of large manufacturing plants is the question of providing efficient methods of transportation for the raw material and the product. The importance of good railroad connections is universally appreciated everywhere, and in localities where water-way shipments are feasible, progressive companies frequently lay out their new works in such a way that both rail and water can be employed in marketing the completed products. In rare instances a manufacturing establishment is located in a retail business and hotel district, the advantages of cheap transportation being off-set by the advertising value of architecturally beautiful buildings constantly in the public eye.

It must not be supposed that because so much attention has been devoted to external transportation in connection with industrial establishments, the internal problem has been neglected. The majority of new factory plants erected in these days are generally well equipped with intramural railways and hoisting facilities, and yet, when the production engineer begins the investigation of a manufacturing establishment, it is his common experience to find gaps in the transportation chain either in the way of inadequate rail lines or insufficient hoisting facilities. Then again, the most elaborate schemes for the speedy handling of materials may be in operation, while the provision of elevators and other facilities for the use of employees may be totally inadequate. With the increasing size of many great plants in some of which some of the buildings may be half a mile or so from the offices—there is no doubt that before long some sort of provision for the horizontal transportation of high-salaried employees will be regarded as of equal importance with vertical movement.

The new plant of the B. F. Sturtevant Company, at Hyde Park, Mass., shows to an admirable degree how much production economy depends upon adequate transportation facilities inside the works. Besides the usual standard-gauge spur tracks, this plant is equipped with an elaborate system of 2-foot gauge railways, numerous traveling cranes, elevators and hoists. From the pig iron

storage yard through the foundry, machine and erecting shops to the testing and shipping departments, the importance of the consecutive mechanical transportation of materials has been constantly borne in mind, and the narrow-gauge system, laid out, as it is, on the checker-board plan, permits the widest variation in movements.

The strength of human beings is required as little as possible, and the machinery in many departments is supplied with working material delivered at any desired angle of convenience. Whenever it becomes necessary to use muscular effort in moving the product, special appliances to facilitate such work are immediately at hand. Forty or fifty different designs of hand trucks are in constant use in the plant, and the saving in time and labour effected by them is remarkable. In these shops the work is brought to the tool, rather than the reverse plan, which means, of course, a wider use of cranes and hoists than is customary under the latter régime. Practically every type of hoist—electric, pneumatic, hand, jib cranes, fixed and traveling cranes—is found here, and it is safe to say that little remains to be desired, as far as the handling of materials is concerned. In one instance the same elevator serves two different departments simultaneously by being operated in a shaft extending vertically through the dividing wall between, doors being located each side.

The means of providing for the economical movement of men and materials in all directions through a large plant are so varied that no detailed discussion of their different peculiar advantages is possible in these comments, but there is no doubt that the loop principle in the layout of narrow-gauge industrial railways is capable of meeting the most exacting requirements of surface haulage. In a very large factory the occurrence of congestion is to be avoided quite as much as on a street railway system. In building operations and heavy and industrial railroading the same general principles apply when we consider the successful handling of materials, and next to the insufficient provision of tools in a modern manufacturing plant, the installation of an inadequate system of vertical and horizontal transporting devices helps most to increase the operating cost of turning out each unit of product. It is not that many admirable facilities are not in use to-day, but the process in many cases is not sufficiently continuous.

POINTS IN THE SELECTION OF DIRECT-CURRENT MOTORS

By George L. Clark

A COMPARISON of the best modern electric motor designs with those of but a few years ago soon demonstrates the fact that remarkable progress has been made in endeavouring to secure that adaptation of means to ends which insures lasting satisfaction to the purchaser and reasonable profits to the manufacturer.

The success of the electric motor in practically every industry which uses power has become so notable that to many purchasers the idea of discriminating between different types and designs of motors seems a foolish waste of time, provided the equipment offered is guaranteed to perform the required service on the basis of reasonably high efficiency and moderate first cost. It is too often the case, however, that motors are bought entirely on the strength of the manufacturer's name, coupled with the lowest bid submitted. Certainly, reputation should be a powerful factor in the selection of any apparatus, but it is far from being the only point worth taking into account.

Let us assume that the purchaser has carefully considered, either personally or through an advisory engineer, the character of the work which the motors are to perform, the conditions surrounding their locations and the type and capacity required for each particular service, whether open, semi-enclosed or enclosed, and of stated horse-power, voltage, and speed. When the horse-power, kind of winding and speed are not specified for a motor needed in a given service, the responsibility for these points should rest with the manufacturer; but in general it is an excellent plan for the purchaser to understand the power requirements of his work, including the approximate suitable speed of each motor and the approximate character of winding, whether series, shunt, or compound.

All motors should be designed with a view to accessibility of brushes, holders, commutators, bearings, wiring and connections. However high may be the reputation of any make of motors for reliability, the possibility of trouble is never absent, and when the time comes for inspection or repairs, ease of access is worth far more than it costs. For example, a partial short-circuit occurs between the brush leads of a motor driving a factory department. If the motor happens to be installed on the ceiling and is not easily opened, the time of a shut-down is correspondingly increased. In a factory where the sequence of operations is continuous and rapid, the delays aggravated by improperly-designed motors may easily cost more in a single hour than the difference in price between the accepted machines and the best motors offered.

In examining semi-enclosed motors submitted with a given proposition, one should make sure that the shape is such as to protect all the parts from external mechanical injury. Openings into the interior should be furnished with cast metal

or wire mesh covers, arranged to secure good ventilation if possible, and to allow, by their removal, easy access to the brush rigging, commutator, and field coils. Enclosed motors should be provided with enough openings to allow easily reaching the interior, and in all such designs dust-proof covers are an absolute necessity if low maintenance expenses are desired.

Ordinary open types of motors provided with separate sheet metal housings sometimes pass as enclosed or semi-enclosed motors, but such machines cannot be said to actually meet the requirements of specifications which call for either of the two latter types. It is an advantage when motor covers can be opened and closed without the use of tools, and an important feature of cover design is a secure fastening which cannot be shaken loose by continued vibration. Hinged covers are, therefore, preferable, other things being equal.

In general, it is desirable that both semi-enclosed and enclosed motors be so designed that they can be changed to wall or ceiling suspension by rotation of the end shields through 90 degrees or 180 degrees. Even though a motor is purchased with the intention of keeping it at work in a single class of service and in a fixed place, changes, unforeseen at the time of purchase, often occur in the arrangement of equipment, with the result that any flexibility which the motor has in regard to location proves to be of great value, often saving the expense of a new motor or special construction capable of supporting the old apparatus in the new way. For instance, a motor may be originally installed on the floor in a brass foundry to drive the pressure blowers, emery wheels and other machinery by belt. The foundry grows in equipment until the only available place for the motor is the wall, which means either a cumbersome platform or a new motor, if the first machine cannot be operated in more than one position.

The number of poles which a motor should have is not a matter of very great importance to the purchaser, but one or two points are here worth remembering. As a rule, the presence of a large number of poles involves an equal number of brush holders, and complicates the commutator problem. On the other hand, bipolar machines do not approach multipolar units in magnetic symmetry, and field distortion and sparking are less easy to handle, while the current density in the brushes tends, in the larger sizes, to mount up above the safe heating limit.

The United States Government requires all motors above 5 H. P. to be of the multipolar type, with the exception of motors for very infrequent service, which may be bipolar up to, and including, the 10-H. P. size. The actual number of poles is thus left to the discretion of the manufacturer along with the details of resistance, magnetic density, dimensions of bearings, armature, field, etc., which should seldom be specified by the purchaser.

A point of much importance is that all parts in a given make, size and type shall be interchangeable, with smooth fits. Endless trouble ensues at times if this provision is not made, and the time of shut-downs becomes needlessly prolonged. The selection of standard, rather than special, machines naturally facilitates interchangeability.

The frames of the best modern motors are either of steel or of a high grade of soft cast iron, with the pole pieces either bolted to, cast with, or cast-welded to the frame. The bases are planed true and parallel to the axes of the shafts, and the construction of the frame and bearings permits the armature to be readily removed. A neat finishing of the frame is preferable to ornamentation, and an eye or ring bolt of ample size and strength for lifting the motor is

a convenience that should not be overlooked.

It is important that all the field poles be equally energized, and that the windings of both armature and field be well protected from mechanical injury and treated with a water-excluding material, which is insoluble in oil or grease. No insulating substance should be used which can be injured by a temperature of 100 degrees C., and no permanent external resistance should be tolerated in the field circuits of any motors. Interchangeable field coils are a great advantage, and the indication of the direction of the winding on some portion of the exterior of the coil or spool is desirable. In the best motors of the compound type the series and shunt windings are separate, all coils are connected in series, and there is no dead wire on the field coils other than that used for the sake of appearance in completing the outer layer. The ends of the shunt coils are brought out with flexible conductors, and the connections between adjacent field coils permit ready disconnection.

In the matter of armatures and commutators, the best designers provide steel shafts of sufficient strength to resist appreciable bending under any condition of overload, ample bearing surface and lubrication by oil rings. Accurately ground journals are important, and some provision should be present to prevent oil creeping from the bearings to the armature. Split oil rings are in some quarters considered undesirable, but in any case the rings ought to be turned true and free from defects.

The bearings should be so designed as to permit visual inspection of oil rings while the motor is in operation, and to be free from loose parts which may become detached and lost. Either babbitt or solid bronze is generally considered satisfactory for the bearing linings. Self-lubricating ball-bearings are now coming into extended use on certain makes of motors, and when such designs are submitted in competition with sleeve bearings, the latter should not receive undue favour if the makers of the ball-bearings offer good guarantees. It is a pretty good plan in doubtful cases to obtain the testimony of other purchasers' experience before finally adhering to any new type of bearing in important service. Oil wells should always be provided with sight glasses, pet cocks for draining and outlets or overflows which will prevent their being filled beyond the proper point, and will allow any excess to flow out.

Armature cores in the most reliable motors are now almost universally of the drum-wound, iron-clad type, built up of thin laminated discs of soft iron or thoroughly annealed sheet steel with space blocks inserted at intervals to assist ventilation. The slots should be punched in the individual discs prior to assembly, the discs being set up under pressure and held securely together by end flanges, the entire core being firmly keyed to the shaft. Insulation between the discs, to prevent eddy current losses, is important. Form-wound coils in all sizes above 5 H. P. are desirable; they should be easily removable for repairs and retained in the slots of the armature body by wedges running throughout the entire active length of the coils. The armatures of first-quality motors are electrically and mechanically balanced, and are free from dead coils; the commutator segments are of pure copper, drawn accurately to gauge, of sufficient depth to allow for wear and turning down, and insulated from the shell by pure mica. Pure mica is also the best insulation for the space between segments, and it is very essential that it shall wear evenly with the copper and be of uniform thickness. No well-constructed commutator exhibits any opening through which foreign substances can reach the interior.

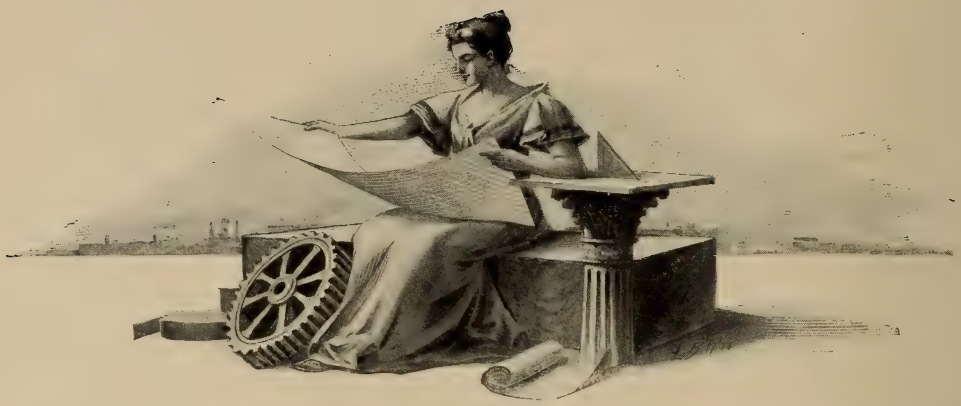
Special attention should always be given to the selection of brushes,

that their material may be homogeneous, and the quality such as to give perfect commutation without cutting or scratching the commutator. Practically all motors used in commercial service are now equipped with carbon brushes, and there is perhaps no feature of motor design which has carried such influence as the carbon brush in establishing the reputation of electric motors for reliability of service. Brush-holder designs now on the market illustrate a variety of ingenious constructions, but all those favourably considered should be readily accessible for adjustment and renewal of springs and brushes, strong and substantial in appearance, separately adjustable for tension, and capable of being removed while the machine is in operation. Any dependence upon brush-holder springs to carry current is bad practice, and on motors requiring more than 15 amperes it is important that flexible connections be used on the brushes unless they are rigidly attached to the holders. It is very desirable that the angle of the brush to the commutator shall not change appreciably, as the brush wears down and the position of the rocker arm for sparkless commutation ought to be plainly marked.

On reversible motors the brushes should be of such design as to permit of armature rotation equally well in either direction without the shifting or changing of brushes, and on motors built for operation in one direction only it is desirable that the brush holders be so made that by very slight changes in the relative position of their parts rotation may be safely reversed. All brushes and holders operating on the same commutator should be perfectly interchangeable. It is difficult to set close limits upon the current density which shall not be exceeded in brush design; conditions vary so widely in different installations. The Bureau of Construction and Repairs of the United States Navy does not permit over 35 amperes per square inch at full load on motors for continuous duty; 40 amperes on variable-speed motors and motors for constant speed, intermittent service; and 45 amperes per square inch on motors for very infrequent duty.

The foregoing points seem to the writer of essential importance in the selection of direct-current motors, apart from the special requirements of each individual case. General though they may be, they have an intimate bearing upon convenient and successful operation. Matters of speed regulation, temperature rise, efficiency and insulation resistance should be defined by the purchaser with his requirements in view, but one should never forget that standard apparatus costs less than special equipment.

The question of acceptance tests falls without the scope of this article, but there is no doubt that it pays to make them, in numerous cases. The minute details of design sometimes specified by prospective purchasers seldom serve to accomplish any good purpose if standard equipment will fill the requirements. The organization of modern factories has been carried so far that in general it is safe to say that the manufacturer knows better than anyone else how to produce a given machine at minimum cost to meet a specific duty. Probably no single motor could be named which possesses all the advantages in the market. But there should be no great difficulty in covering the general requirements here suggested.



Current Topics

THE point about steam turbines to which most prominence seems to have been given in all discussions of their use for ship propulsion is their larger coal consumption as compared with reciprocating engines for equal service; in fact, for both merchant and warships, this point has been emphasized to the almost entire exclusion of every other consideration, so that it may well be questioned whether the matter has not been very much overdone. The ship owner has for many years been taught to believe, by experience and otherwise, that coal consumption is everything, and that very little else counts. It is his time-honoured measure of the profits of the average trip. But there are other things quite as directly involved in the business part of the ship owner's problem. The saving in space, for example, which the steam turbine effects beyond all question, the saving in attendance also, and the saving in the maintenance account all are factors of such magnitude in connection with the money-making capacity of a vessel that their combined influences may safely be asserted to very materially overbalance the 10 per cent. increase in the coal bill for which the turbine is said to be responsible. There are still other considerations in favour of the marine turbine,—saving in weight of machinery; ease of accommodation below the water line, in warships, without cramping the designer; freedom from oil troubles in the boilers due to the returned water of condensation,—offset more or less by drawbacks of which something has already been heard, with fuller knowledge promised in the near future. When this comes we shall have a more accurate measure of worth than is afforded by the speculative reasoning of the present. In the meantime the turbine ship should not be forejudged.

THE overload capacity of a gas engine is a matter about which buyer and seller alike ought to have a clear understanding. It will help to avoid later disappointment to both. Arthur West, chief engineer of the Westinghouse Machine Company, in dwelling on this point in a recent paper detailing the good features of gas engines for electric railway work before the American Street Railway

Association, explained that the power of a gas engine is limited by the total volume of explosive mixture which can be drawn into the cylinders during the suction stroke, compressed, and finally ignited. This condition sets a limit which does not allow of a large temporary increase of the power. Overload capacity is, of course, convenient for the purchaser, but it is unobtainable on a gas engine, unless the engine is largely underrated, and the purchaser should consider that this is one of the prices that he pays for the enormously increased output obtained with the gas engine per pound of coal. The overload capacity is, therefore, simply the amount which the builder rates his machine below its ultimate capacity. It has been the practice of some builders to rate their gas engines in such a way that they would have a safe overload capacity of 10 per cent. Some engines are ordinarily good for somewhat more than this, but conservative engineering requires that there be a margin of power in order that overloads may not materially reduce the speed. The above remarks on overload furnish a general guide which may be of service in selecting suitable generator capacity for a gas engine. For ordinary cases the overload capacity of the generator and that of the gas engine should be about equal, although the gas engine will indefinitely carry its overload while the generator will not, in all cases, unless it is bought with that understanding.

The development of new lines of rapid transit for the purpose of relieving traffic congestion is a common experience of great cities in these days, and the projects now under way in some of the largest centres of population in America and Europe are rightfully a source of pride to every friend of real progress. There is little doubt that we are scarcely at the beginning of rapid transit development, measuring present facilities by the commercial and engineering possibilities of the near future. Ordinary trolley service may be rapid transit in comparison with the earlier facilities for traversing great cities, but it is far from equal to the demands in the way of time-saving which arise daily in metropolitan centres.

According to the report of the Royal Commission on London traffic, the average resident of London uses two hours a day in going to and from his work. The Commission endeavours to show how this enormous waste of time can be reduced, and in its report presents some eight volumes of suggestions for large new streets with four lines of cars above and below, two avenues, twenty-three new transportation routes or extensions, new bridges and the development of a central rapid transit system under a single management. The cost of carrying out such a scheme is enormous, for it involves the condemnation and destruction of a vast amount of valuable property, quite apart from the cost of construction and the inconvenience which must be temporarily borne by the inhabitants of the business district. In the several large American cities the rapid transit problem is also of pressing importance, and vast sums of money are being expended to relieve the situation. Such expenses cannot well be avoided,—in fact the growth of great cities justifies the financing of such projects as the New York Subway system, with the expectation of reasonable profits in operation. In some quarters it has been claimed that new rapid transit routes increase congestion instead of reducing it, but the fact is that the development of the tall office building and high-speed elevator has been such a powerful factor in concentrating population, that if it were not for the rapid transit lines—which often cannot keep pace

with a city's growth—the congestion would be intolerable instead of merely wasteful and annoying.

THE use of every feasible agency to facilitate the movement of people and merchandise is therefore of great importance, but in studying various schemes for relief, the influence of the telephone in relieving congestion by keeping people off the streets has often been entirely overlooked. This point has been emphasized to excellent advantage in its bearing upon conditions in London. People use up too much energy in running about the streets, like animalculæ in a glass of water, and do not avail themselves sufficiently of the time-saving equipment which is at their disposal. To a large extent the telephone eliminates the necessity of making personal calls entailing the use of the streets, but where the telephone service is very inferior, it is largely the custom to make personal trips by cab or afoot rather than to suffer the annoying delays which inefficient telephone operation entails. It is next to impossible to express in figures the influence of good telephone service in relieving urban congestion, but if the exchanges in any great city should go out of business for a single day, a very definite idea of this influence would be forced upon the public. The pneumatic tube is also to be a factor of great importance in the urban life of the near future, and improved methods of transporting heavy merchandise are bound to be instituted before many years in all of the larger cities of civilized lands.

THE history of motive power machines, says "The Engineer," of London, is full of interest. No sooner do we appear to have reached finality in any one direction, than something is done, some new invention made, some improvement effected, and we begin all over again with a new departure. The most economical steam engines were beaten by the gas engines, which got down to a consumption the equivalent of about 1 pound of coal per indicated horse-power per hour. The steam engines just managed to scrape through with about 50 per cent. more. Then superheating was revived, and, after a hard fight for territory, it has come to stay, and with its aid, small clearance, piston drop valves, and first-rate workmanship, a consumption of 10 pounds of steam per indicated horse-power per hour has been reached, and as a boiler can be made which will give 10 pounds of steam per 1 pound of coal, the best work of the gas engine has been rivalled. But the oil engine is another competitor which has not been suffered to remain unimproved. The Diesel engine is, so far as weight of fuel per indicated horse-power is concerned, the most economical heat motor in the world. But it is run very close by other engines which are reputed to require less than half a pound of oil per indicated horse-power per hour. In so far as relates to mere size, the steam engine still remains pre-eminent, and will probably continue to do so for a long time to come. The suction gas producer engine has, at all events, yet to be designed which will be suitable for an Atlantic liner. But there is no lack of competent inventors who believe that such a design can be made, and if carried out on a large scale, we shall have long-voyage gas ships beating the best results hitherto attained by 20, if not by 50 per cent.

SPECIALIZATION, which, by many, has been regarded as something largely of American origin, at least in so far as the engineering trades are concerned, is not what Dr. Samuel B. Christy, professor of mining and metallurgy at the University of California, would recommend in the training of the mining engineer, par-

ticularly not in the case of the American mining engineer, even though this may, at first thought, appear anomalous. For the mining engineer, Dr. Christy maintains, in a paper read before the American Institute of Mining Engineers, great breadth of training is necessary. Like the soldier or sailor, he must go to the ends of the earth. His work often lies beyond the borders of civilization, where, like Prospero upon his lonely isle, he must conjure up his resources from the vasty deep, and he must act in turn as geologist and as civil, mechanical, hydraulic, electrical, mining, or metallurgical engineer. The problem is, what degree of specialization shall be undertaken in an undergraduate mining course? Shall we endeavour to turn out at graduation specialists, each completely equipped for work in some narrow line, or shall we rather attempt to establish a broad basal training in the physical sciences on which the future engineer may safely build, as circumstances may require? The former system, says Dr. Christy, is the European practice, such parallel courses as mining engineering (further subdivided into coal and metal-mining), metallurgical engineering (also subdivided into two branches), mine-surveying, mine-geology, and the like, being commonly recognized departments within which the student specializes in an undergraduate course. In an old community, where the mines are under government control, and customs have crystallized, such a specialization is wise. Each student can estimate with certainty the need for the specialty he chooses, and be sure of employment in his own line. But under other conditions, as in America, it is unsafe to specialize too soon and on too narrow a basis. Here the mere specialist, outside of his specialty, is as helpless as a hermit crab outside of his shell, and unless he possesses the ability to adapt himself speedily to a rapidly changing environment, is sure to go under. The present age is one of rapid change in all industrial and engineering methods, such as has never before been seen in the world. Old established processes are being continually swept aside and replaced by new ones. These changes occur with kaleidoscopic speed and unexpectedness, and the man who has painfully armed himself with precedent and ancient lore finds himself hopelessly beaten before he can even make a start in the race.

As to mathematics for engineers, Dr. Christy, in the same paper, takes the stand that no man is fit to teach it who has not had some experience in its applications either to engineering, to physics or to astronomy. For only such a man knows just what to emphasize and what to omit, how to sympathize with, and how to inspire his students. Men of prime ability in the mathematical faculty are absolutely the first essential in any engineering school. It is wonderful how difficulties melt away like wax in the fire with a really able mathematical teacher. By such a teacher mathematics can be made as interesting as a romance to the average man, while it is often regarded as hopelessly difficult merely on account of the poor hands in which it is placed. To make new discoveries in the field of mathematics requires genius of a high order, but to master all the mathematics necessary for the intelligent practice of engineering requires no faculties beyond those of a logical mind, a certain power of imagination, and a reasonable degree of application. Dr. Christy says that he has always found that the students who do well in mathematics do well in everything else that requires close thinking. Instruction in physics and in mathematics should go on side by side, and the two courses should be so arranged that the mathematical principles may be at once applied to physical problems of a useful nature. The importance of actual numerical results should be always insisted upon.

FREDERICK WINSLOW TAYLOR

A BIOGRAPHICAL SKETCH

The New President of the American Society of Mechanical Engineers

By H. L. Gantt

IN the work of every man who rises above the crowd, there is usually some portion that is especially characteristic of the man and illustrates why he has risen.

If we study the work of Frederick Winslow Taylor, we find all of it stamped with his personality, and hardly a piece that does not bear evidence of having been done by a master hand. As an engineer, his delight is to solve those problems at which others have failed, and his ability to pursue unceasingly for years a cherished object has crowned his work with success.

If I were asked which piece of work more than any other illustrates his character as a man and an engineer, I would say the determination of the laws for cutting metals.

Finding himself balked at the outset of his career by a lack of knowledge on this subject, and realizing the great advantage the knowledge of these laws would be to him and to the engineering profession in general, he determined to find out what they were. Suffice it to say that, although warned by his friends that he was attempting the impossible, and that for the first five years he scarcely made any real progress toward the desired end, he persisted in his work, to be rewarded after more than twenty years not only with a complete solution, but with the satisfaction of seeing the laws reduced to slide rules for their rapid application.

The difficulty of this problem can be understood only when it is known that there were not only no precedents and no standards, but that even the method of devising standards had to be developed. The first standard needed was a method of hardening cutting tools so that their cutting properties would be the same.

It was his persistent attempt to get uniformity in cutting tools that led, nearly twenty years later, to the discovery of the Taylor-White process, which is the only method known of producing tools whose cutting efficiency varies less than 1 per cent. This whole investigation involved at least fifty thousand experiments and cost probably over one hundred thousand dollars; the fact that he was able to carry to a successful conclusion such a gigantic undertaking in the face of the lukewarm support of his friends, and the determined opposition of all others, is a testimonial to his strength of character which needs no comments.

The solution of this problem will always be connected with his name, and the book on Taylor's laws to be published shortly by himself will soon be recognized the world over as one of the greatest pieces of scientific investigation of the nineteenth century.

His discovery, in connection with Maunsel White, of the Taylor-White process of treating steel is a piece of scientific investigation almost as remarkable, and in its results quite as far reaching, for it is the basis of all the modern high-speed tool steels which have so much reduced the cost of cutting metals. This discovery

was the natural result of his habit of making a thorough investigation of every problem with which he was confronted, and fully justifies his practice of carrying investigations to their logical conclusions, even though such conclusions seem contrary to all previous experience.

Mr. Taylor was the first man to study scientifically the ordinary labour problems, and to determine exactly how much work of various kinds a good man suited to it could do. His determination of the elementary periods of time needed to perform each elementary operation of which a complete operation is composed, is best described by himself, as follows:—

"In the field of management the one question which is the most frequent subject of discussion between employers and employees—which causes more disputes and strikes than any other is, how much work a workman should be called upon to do for a given amount of wages; in answering this question, both the workman and the employer are in ninety-nine cases out of one hundred handicapped by the fact that neither knows accurately how quickly the work under discussion can be done.

"The extreme ignorance, in most cases, of both employer and employee as to the time required to do work, is astounding. This lack of time knowledge is great even in the more simple kinds of work performed by day labourers, such as shoveling and handling raw materials; and the more complicated the work, the less accurate is the 'time' knowledge.

"Practically all of even the most systematic and painstaking employers now derive their knowledge of how much of a given class of work can be done in a day, either from their own experience, which has frequently grown hazy with age, from casual and unsystematic observation of their men, or at best from records which are kept, showing the quickest time in which each job has been done. When workmen realize that their employers are keeping time records for the purpose of gaining this knowledge, they systematically go slow or 'soldier' with the deliberate object of keeping them ignorant as to how fast work can be done. So universal is soldiering for this purpose, that hardly a competent workman can be found in a large establishment, whether he works by the day or on piece work, contract work, or under any of the ordinary systems, who does not devote a considerable part of his time to studying just how slow he can work and still convince his employer that he is going at a good pace. The causes for this are, briefly, that practically all employers determine upon a maximum sum which they feel it is right for each class of employees to earn per day, whether their men work by the day or piece. Each workman soon finds out about what this figure is for his particular case, and he also realizes that when his employer is convinced that a man is capable of doing more work than he has done, he will find sooner or later some way of compelling him to do it with little or no increase of pay.

"In spite of the records kept by employers, the writer has seen many jobs successfully nursed in several of our large and well-managed establishments for a term of ten to fifteen years, at from one-third to one-quarter speed, the workmen, in the meanwhile, enjoying the confidence of their employers. In 1883, while foreman of the machine shop of the Midvale Steel Company, of Philadelphia, the writer concluded that the plan of keeping records of the times in which various jobs were done was not only of little value to himself, but that it tended to make all of his workmen hypocritical and deceitful. He therefore decided to abandon the indirect method of time study through records made after the job was done, but to attack the time problem directly by standing alongside of the workman with a stop watch, pencil, and properly ruled and printed ob-

servation blanks, and in this way studying, not how long the man actually took to do the work, including needless motions, delays and slow movements, but how quick the job could be done when the man worked steadily, fast, and to the best advantage. This was the beginning of making direct time study.

"The results were most satisfactory, and the writer was surprised to find that his workmen accepted without question the speed of doing work which he had determined as correct after careful direct time study. He also found that first-class men can in most cases do two or three times as much work as is done on an average, and that they are not only willing but glad to work at their maximum speed providing they are paid from 30 to 100 per cent. more than the average wages of their trade.

"During the past twenty years the writer has spent most of his time in systematizing manufacturing establishments, large and small, covering a great variety of work, and in many parts of this country. With accurate time study as a foundation and by paying a premium of from 30 to 100 per cent. beyond the average wages, he has never failed to get the men to double or treble their output. During this time he has never been opposed by a strike or had any serious labour trouble, in spite of the fact that any endeavour to get men to increase the speed of their work is usually resented by workmen and meets with strenuous and effective opposition. Now there are thousands of men working contentedly under this system, at peace with their employers, and no labour agitator could persuade them that the old system of dealing periodically with their employers through their union leaders, with the accompanying strikes and lockouts, is preferable.

"Time study is fast becoming a trade or profession, occupying relatively the same position to the art of management that drafting does to engineering. It has its own appropriate implements and methods, and should not be undertaken without investigating the ways of those who have made it their specialty. It is a study, not of the time required to do whole jobs of work, but of the time which it should take to do each small element into which all jobs can be subdivided, which constitutes scientific time study.

"The writer's experience has been that the difficulties of scientific time study are underestimated at first, and greatly overestimated after carefully applying the system for two or three months. The average manager who decides to undertake the study of 'unit times' in his works, fails at first to realize that he is starting in a new art or trade. He understands, however, the difficulties which he would meet with in establishing a drafting room, and would look for but small results at first if he were to give a bright man the task of making drawings who had never worked in a drafting room and who was not even familiar with drafting implements and methods, but he entirely underestimates the difficulties of this new trade.

"The art of studying 'unit times' is quite as important and as difficult as that of the draftsman. It should be undertaken seriously, and looked upon as a profession. Without the use and understanding of proper methods and implements, progress will be exceedingly slow and there will be more failures than successes.

"On the other hand, an energetic and determined man goes at 'time study' as if it were his life's work, with the determination to succeed, and the results which he can secure are indeed marvelous. Inasmuch as the difficulties of the task will be felt most strongly at the beginning, it seems important to encourage the beginner by giving at least one illustration of what has been accomplished.

"Sanford E. Thompson, C. E., of Newton Highlands, Mass., started in 1896 with but small help from the

writer, except in so far as the implements and methods were concerned, to study the time required to do all kinds of work in the building trades. In six years he had made a complete study of eight important trades, —excavation, masonry, bricklaying (including sewer work and paving), carpentry, concrete and cement work, lathing and plastering, slating and roofing and rock quarrying. He took every stop-watch observation himself, and then with the aid of two comparatively cheap assistants, worked up and tabulated all of his data ready for the printer. The magnitude of this undertaking will be appreciated when it is understood that all of the tables and descriptive matter for one of these trades alone take up about 250 pages. Mr. Thompson and the writer are both engineers, but neither of us was especially familiar with the above trades, and this work could not have been accomplished in a lifetime without the study of elementary units with a stop watch."

Illustrations, such as the one given by Mr. Taylor, might be multiplied almost indefinitely, but all would show his devotion to and reliance upon the scientific method.

His work in the field of constructive engineering is no less remarkable, and the great hammer of the Midvale Steel Company, the largest in America, stands as a witness to his faith in the scientific method. This is the one steam hammer in all the world that yields to the strain of a foul blow, and by its elasticity recovers its proper alignment.

His passion for scientific knowledge is supplemented by his ability to use it, and the combination of the two has resulted in the Taylor system of management, where each step in any kind of work is planned in accordance with exact knowledge, which eliminates all possibilities of failure.

Under the Taylor system of management, each man is forced to work in harmony with the others, and the output of a plant is seldom less than three times as great as it was before the introduction of this system, and often five times as great.

In order to perfect the system it was necessary to have an impartial critic of its efficiency. This was found in a proper cost-keeping system, which again Mr. Taylor found it necessary to develop. His system of cost-keeping enables a manager to pick out with unerring certainty the cause of any unusual cost or waste in work of any character.

Although his qualities as an engineer command the admiration of all, his attributes as a man are quite as remarkable, and those who know him best, prize him even more as a man than as an engineer. His friends are quite as numerous among the workmen he has come in contact with, as among his social equals, and those who have had most to do with him freely testify to the benefit they have received from his training and methods. Especially is this true with young men who have worked under him, and his success with them has been due to the fact that while an uncompromising and strenuous taskmaster, he has recognized the value of time as an element in training, and has been able to overlook the frequent personal issues which those who do not understand his methods insist in raising at every turn. His remarkable ability to look beyond such issues and to see in them only incidents in the operation of broadening a man's view of work and duties, causes those who have once worked under him and understood his ideals, to regard him ever after as a friend who is always ready to give to his assistants full credit for their work.

Although his name is connected with many advances in engineering and management, he is still a young man. He was born in Germantown, Pa., in 1856, and at the age of 18 entered Harvard College, having been prepared at Phillips Exeter Academy.

Soon after entering college his eyes

became affected and he had to give up study. He at once determined to get his education in another way, and began to serve his apprenticeship as a pattern maker in the works of William Sellers & Company. In order to make as rapid progress as possible and to get some special advantages, he worked for less pay than the other apprentices, and in four years not only became a pattern maker, but also served an apprenticeship as a machinist and learned to run every tool in the shop. When he completed his apprenticeship in 1878, times were so dull that he could not get work at his trade, but went to work in the machine shop of the Midvale Steel Company as a labourer.

His first promotion was to the position of shop clerk, after which he was given charge of the tool room. As head of the tool room he saw the advantage of having all the shop tools ground by one man, and instituted this reform, inventing the Taylor grinder for the purpose. From head of the tool room he became successively gang boss, assistant foreman, and then foreman of the machine shop. Next he became master mechanic in charge of repairs and maintenance of the works, then chief draftsman, and in 1884 chief engineer of the works, thus advancing from labourer to chief engineer in six years.

Soon after he entered the Midvale Steel Works, he began to feel the need of a more complete engineering education, and in 1880 began to study at night the engineering course of the Stevens Institute of Technology in addition to his work of ten hours per day. The fact that he passed all his examinations and graduated in 1883 with practically no assistance from any teacher is an evidence of his ability and industry; these characteristics also go far toward explaining his subsequent success.

In 1890 he left the employ of the Midvale Steel Company to become general manager of the Manufacturing Investment Company, whose business was operating large chemical pulp mills. In this work he first came in touch with some of the great financiers, whose principle that success justified any means needed to obtain it, did not appeal to him. At the termination of his contract with this company in 1893, he severed his connection with it, and from that time to 1901 was engaged in introducing his system of shop management into various kinds of manufacturing and engineering establishments.

During these eight years his system of management won a position from which it can never be displaced. The greatest virtue of this system is the feature that makes it most difficult to introduce, namely, that it demands efficiency on the part of the manager as well as on the part of the workman and shows up with absolute impartiality the short comings of both.

Together with Sanford E. Thompson, C. E., he recently completed a very extensive book on concrete and its various uses. This book contains the latest information and much that is entirely new. During the past twenty years Mr. Taylor has collected, developed and applied vast amounts of knowledge on the art of management, and he is now engaged in putting this in proper form for publication. His habit of developing an idea and putting it in concise form is well illustrated by the fact that he has taken out over fifty patents, most of which cover machines or processes that are in actual use.

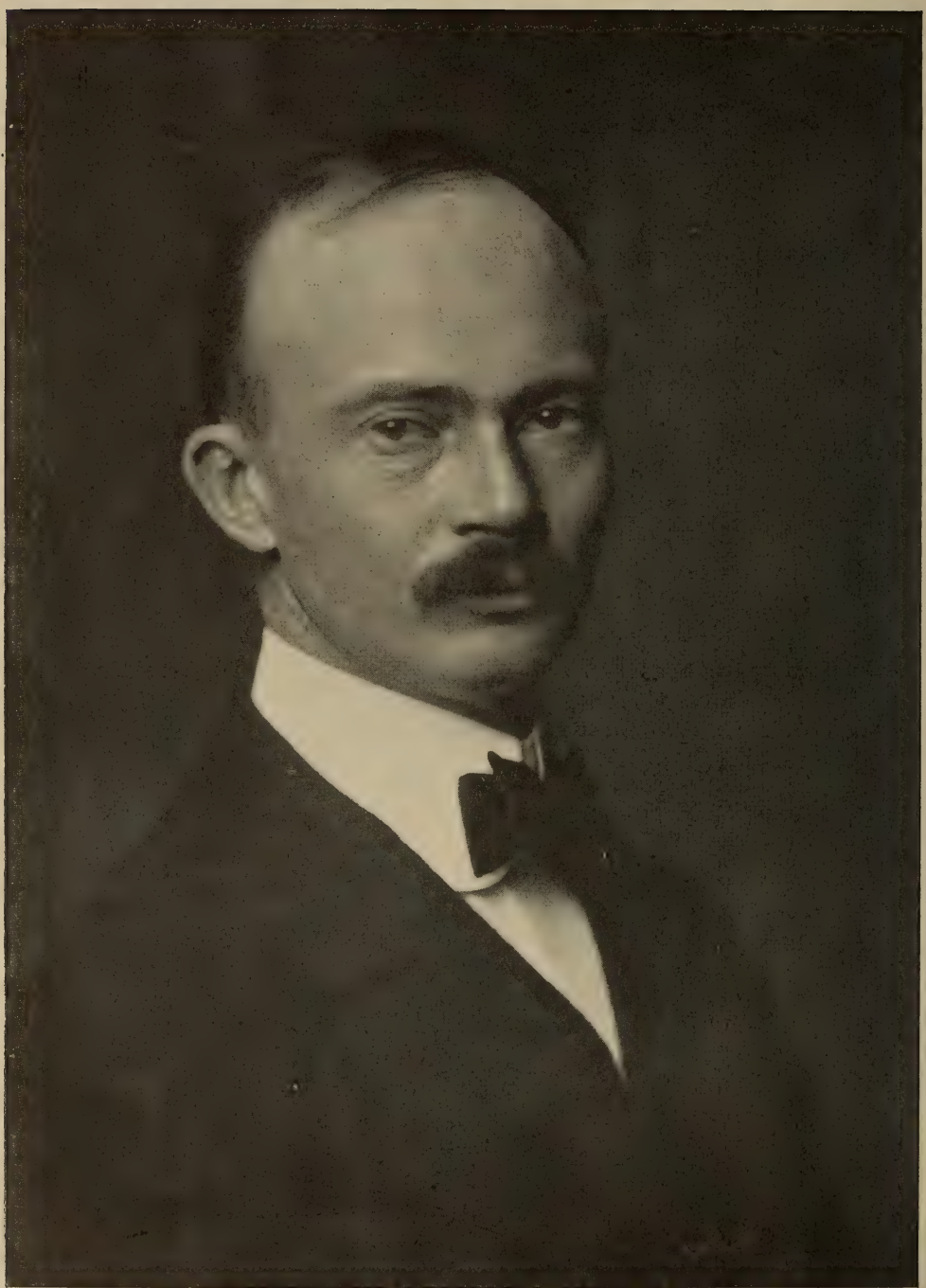


PHOTO BY HOLLINGER & CO., NEW YORK

WILLIAM BANCROFT POTTER

ENGINEER OF THE RAILWAY DEPARTMENT OF THE GENERAL ELECTRIC CO., SCHENECTADY

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CASSIER'S MAGAZINE

VOL. XXIX JANUARY, 1906 No. 3

THE LARGEST TURBINE STEAMSHIP IN THE WORLD

THE "CARMANIA" OF THE CUNARD LINE

By Archibald S. Hurd

IT is only a bit more than eight years ago that the little steamer "Turbinia," equipped with the Parsons type of marine turbine, created a sensation at the Diamond Jubilee review at Spithead, when she astonished all onlookers by the ease with which she sustained a speed regarded until then as impossible to attain. The "Turbinia" was little more than a toy, but her success at once riveted attention on the future of this new form of marine engine. On the one hand, optimists prophesied that the turbine would shortly drive the reciprocating engine off the seas and, on the other, pessimists contended that, although it might prove useful in vessels in which the highest speed was the main consideration, it would be found that the coal consumption would prove too great to warrant its use in other vessels.

At the present time, however, the huge Cunard turbine liner "Carmania" has completed her first round trip between Liverpool and New York. She is the largest vessel ever built upon the Clyde, so large in fact that in going down from the Clydebank yard of her builders, Messrs. John Brown & Co., she touched the bottom and scraped one of her propellers; fortunately the damage was very slight. The "Carmania" is the largest turbine ship in the world, and will remain so until the launch of the two express Cunarders which are now being built, one by Messrs. John Brown & Co., at Clydebank, and the other by Messrs. Swan, Hunter & Wigham Richardson, at Wallsend-on-Tyne. Her dimensions are:—

Length over all	672 feet
Breadth moulded	72 "
Draught of water laden	32 "
Displacement	29,866 tons

Between the completion of the "Turbinia" and her sensational appearance at Spithead and the commencement of the construction of the turbine-driven Cunarder, a great deal has occurred which has thrown light upon the problems introduced by this new form of ship propulsion. The

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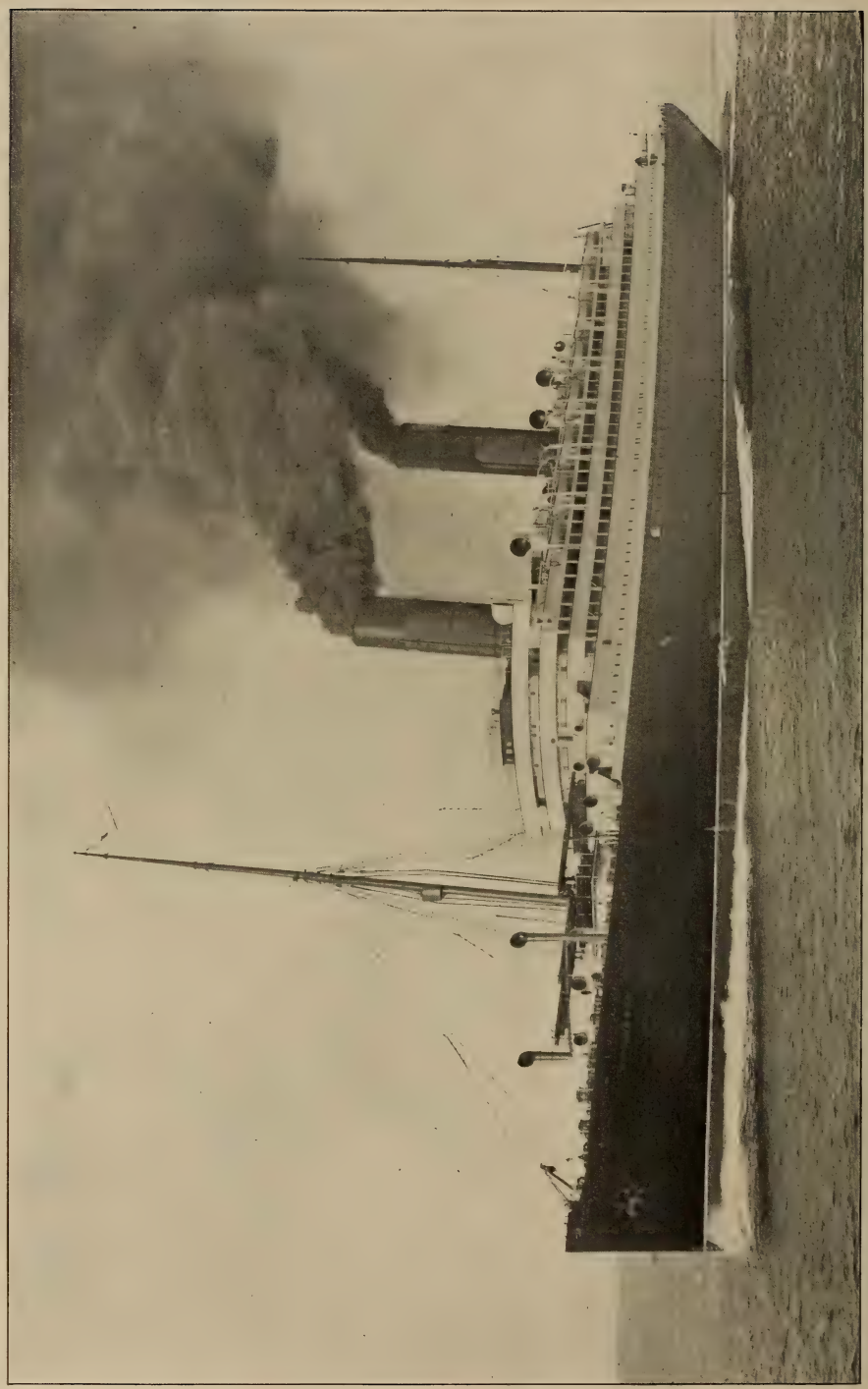
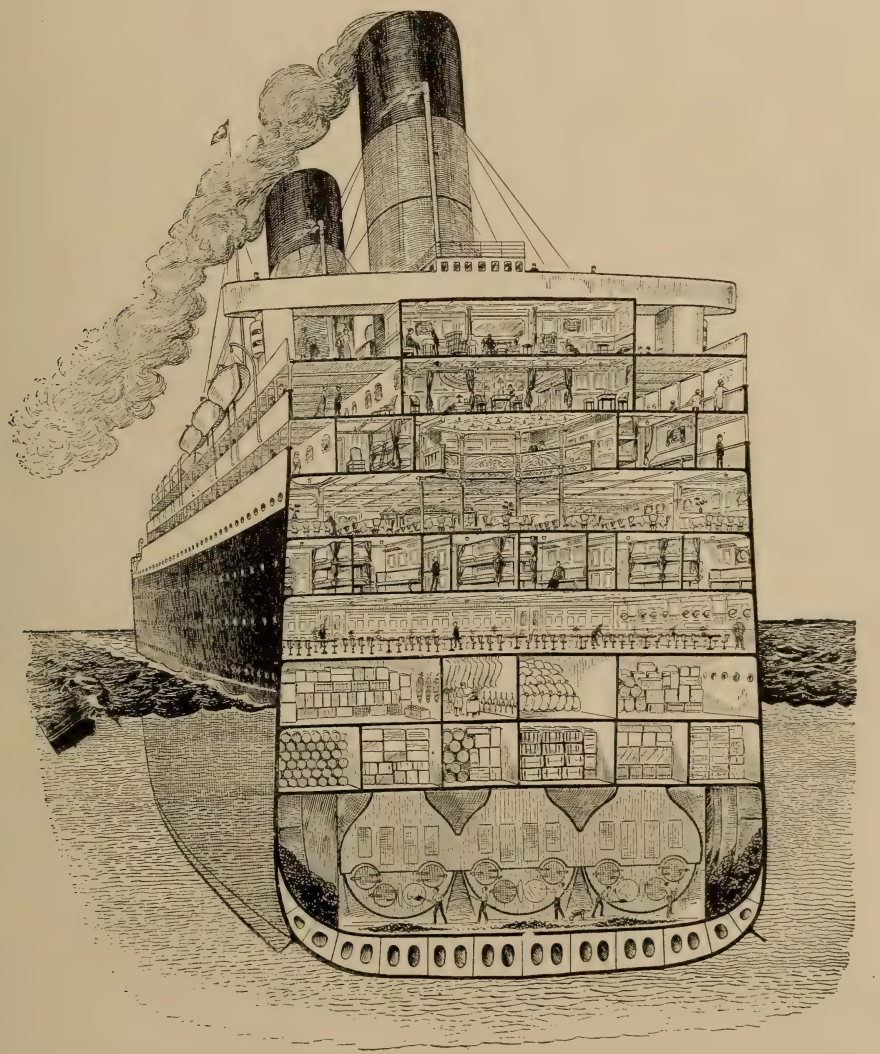


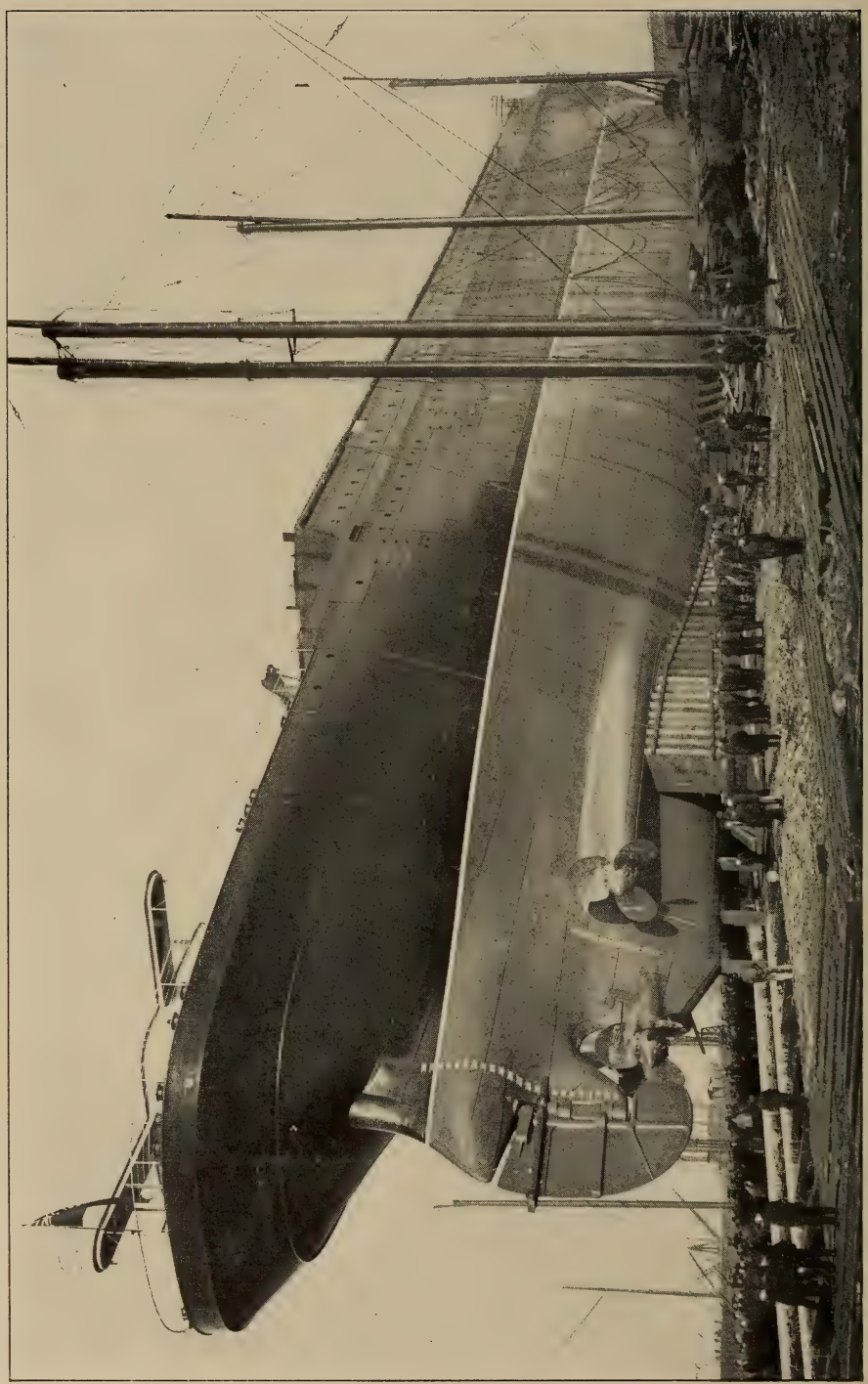
THE TURBINE STEAMSHIP "CARMANIA," OF THE CUNARD STEAMSHIP CO., LTD., ON THE MEASURED MILE. LENGTH OVER ALL, 672 FEET. BREADTH, 72 FEET. SERVICE DRAUGHT, 33 FEET. DISPLACEMENT AT THIS DRAUGHT, 30,918 TONS. HORSE-POWER, ABOUT 21,000. SIX-HOUR TRIAL-TRIP SPEED, 20.19 KNOTS. BUILT BY MESSRS. JOHN BROWN & CO., LTD., CLYDEBANK

Parsons turbine is a British product, and therefore from the first commended itself to engineers in the United Kingdom. No sooner had the advantages claimed for it been formulated, than efforts were made to arrive at a just appreciation of its merits. It was first of all adopted in a number of steamers intended to make the short runs between England and the European continent on the one hand, and between Welsh ports and Ireland on the other.

In a few instances these early turbine-driven ships did not realize anticipations, but it was conjectured that this was in large measure due to inexperience in their construction. At any rate, the general consensus of opinion among marine engineers was in favour of the advantages of the turbine, and the Cunard Steamship Company determined to study this great rival to the reciprocating engine with a view to eliciting the advantages which it offered over the



TRANSVERSE SECTION OF THE "CARMANIA," SHOWING THE ARRANGEMENT OF DECKS AND COMPARTMENTS



THE "CARMANIA" BEFORE LAUNCHING. TWO OF THE THREE PROPELLERS ARE HERE SHOWN

IN THE FIRST-CABIN SMOKING ROOM

reciprocating engine in the largest ships. The enterprise of this corporation was all the more significant because on the Continent of Europe, even in Germany, the matter was at that time attracting little attention, so convinced were foreign engineers whose experience in marine turbines was then confined to other types, that this new form of propulsion was still in too early experimental stages.

The Cunard Company recognized that they would be compromising themselves seriously if they proceeded in haste, but at the same time they realized that if they were to regain the blue ribbon of the Atlantic, held for several years past by German liners, they could not afford to ignore the assistance which the Parsons turbine might afford. The late Lord Inverclyde, the chairman of the company, decided that the first step should be thorough inquiry into the possibilities of the turbine, and an expert commission was forthwith appointed in which the British Admiralty was represented. As a result of the report of this body, the Cunard Company placed orders for the equipment of the "Carmania" and two additional Atlantic liners with turbine machinery. The order for the "Carmania" went to Messrs. John Brown & Co., of Clydebank, and this great firm, which has been so long associated with the Cunard Company, realized that their reputation as well as that of the Cunard Company depended upon the success with which they carried out this initial installation of turbine machinery in a great and an expensive ship of this class. Before a beginning was made with the building of the turbines a long series of practical experiments were made at the Clydebank yard, under the direction of Thomas Bell,

A CORNER IN THE FIRST-CABIN DRAWING ROOM

superintending engineer, in order to solve a number of problems which the task before them suggested. These experiments were carried on for a long period at great expense, and before the construction of the machinery for the "Carmania" was put in hand the builders were satisfied that they were on sure ground and that the turbine was the mode of propulsion of the future.

The new Cunard liner is sister ship to the "Caronia." The latter vessel, however, has reciprocating engines. In all other respects the two ships are exactly alike, and accordingly afford excellent opportunity for comparative trials. The "Caronia's" machinery is a development of that of the "Saxonia," which was proved by the Naval Boiler Committee to be the most economical ship afloat tested by them, so that the "Caronia" constitutes a record standard for comparison.

Testimony to the organization and equipment of the Clydebank yard is supplied by the fact that the "Carmania" was launched in an advanced stage within twelve months of the laying of her keel, and notwithstanding the unprecedented size of the turbine machinery and of the difficult questions associated with its details of design and construction, the vessel was completed for service in little more than twenty months.

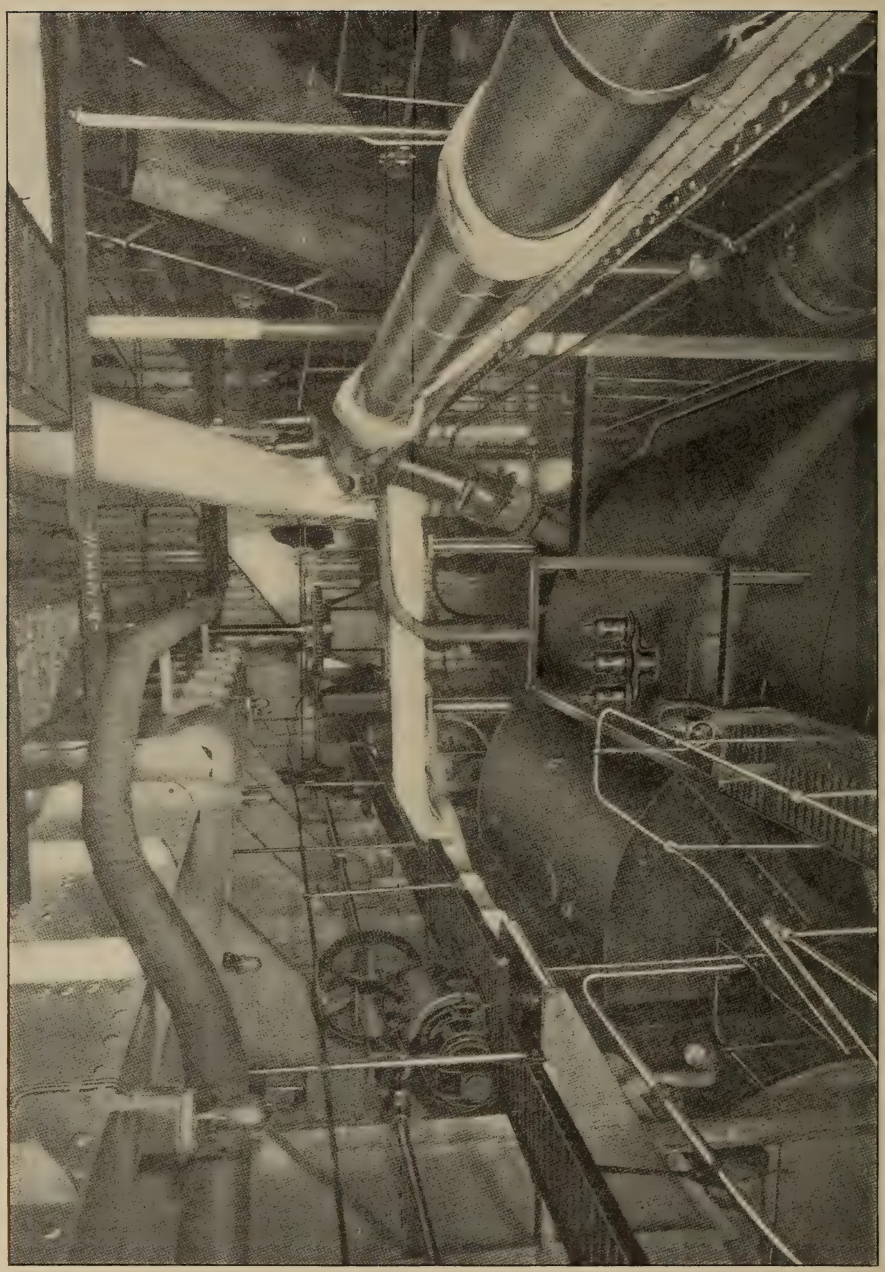
The builders state that many advances have been made in connection with the structure of the ship, so as to enormously increase the strength, and to prevent the "working" which is too frequent in some modern vessels. The keel plate is of exceptional thickness. There is a very soundly built double bottom, which may be used for water ballast so as to bring the ship to a draught that will help to make her comfortable in any seaway. The total capacity for water ballast is 3450 tons. With the same object of rendering the ship steady in heavy seas, very deep bilge keels have been fitted amidships for

about half the length of the vessel. Besides the double bottom, there are 12 bulkheads across the ship binding her together, and at the same time insuring safety in case of collision. The stern frame is a massive structure weighing about 50 tons. In order to give greater strength, a considerable amount of the plating on deck and shell has been doubled in thickness, and the plates used have been of exceptional size, averaging about 3 tons in weight. Most of the riveting was done by powerful hydraulic machinery.

The vessel was designed to maintain a continuous speed at sea of 18 knots. The turbine machinery consists of one high-pressure turbine placed on the center line of the ship, and two combined low-pressure and reversing turbines placed in the two wings respectively, there being, thus, three shafts, each driving a propeller. Owing to the large power to be developed, and the consequent unusual size of the turbine casing, special arrangements had to be made to prevent distortion and also to allow for expansion. The turbine drums, the shafting, and the steel castings were made at the Sheffield works of the builders. The main condensers are cylindrical, and the circulating water is supplied by two powerful centrifugal pumps, each of the pumps having two direct-connected engines.

ONE OF THE FIRST-CABIN STATEROOMS

What impresses one most when inspecting the engine room is the enormous size of the turbine casings. The low-pressure turbine casings are 14 feet outside diameter and 36 feet long. There are eight double-ended and five single-ended boilers, working at a pressure of 200 pounds per square inch. These are arranged in two separate boiler rooms. The funnels rise to a height of 135 feet above the level of the furnace. The boilers are fitted with Howden's heated



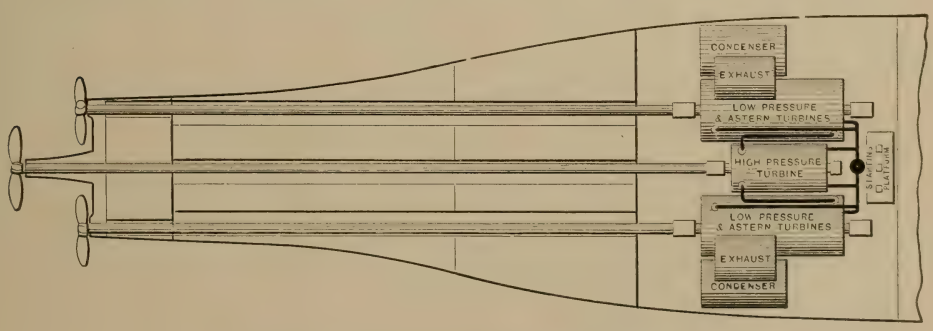
A VIEW OF THE "CARMANIA'S" ENGINE ROOM FROM THE UPPER GALLERY
By Kind Permission of "Engineering"

ONE OF THE PROMENADE DECKS

forced draught system, supplied by two large fans, each driven by two engines.

In this vessel the principle of driving the auxiliary machinery by electric motors has been developed to a considerable extent, and special attention has been given to the disposition of fans for the ventilation of the extensive passenger compartments.

In addition to the usual telegraph and telephones to the engine room, the after bridge and to the bow, there is an installation for the control of the whole of the water-tight bulkhead doors. These doors are fitted on the Stone-Lloyd principle, and can at the will of the captain be closed throughout the ship in a few seconds, thus rendering the vessel practically unsinkable. Another interesting instrument fitted here is a submarine telephone, an appliance for locating the position of lightships or lighthouses in foggy or thick weather, by



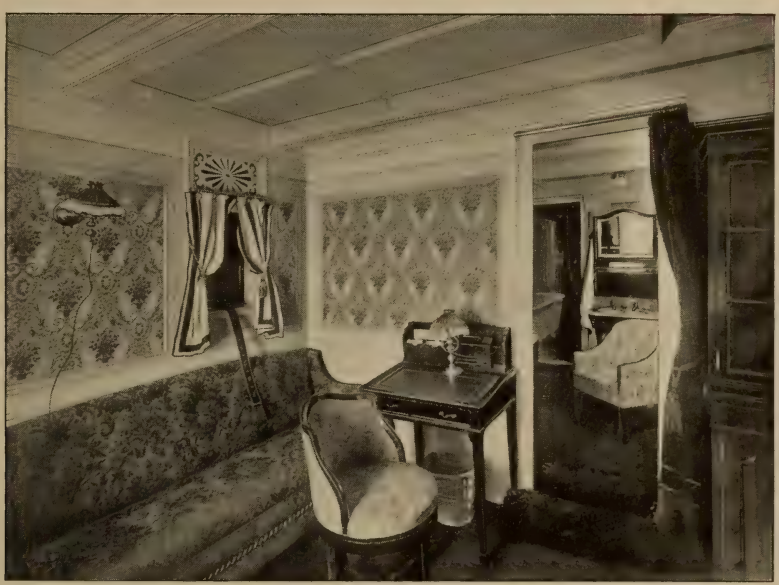
THE GENERAL LAY-OUT OF THE THREE TURBINES

A PORTION OF THE FIRST-CABIN DINING ROOM

means of sound waves through the water. By this appliance, which is fitted on all the New York and Boston passenger vessels of this company, a submarine signal was recently distinctly heard as far as 9 miles away. On the boat deck there is a Marconi wireless telegraph station, forming a link by which the ship is in touch throughout the voyage with Great Britain or America, receiving news or messages for passengers daily.

Now that the "Carmania" is in regular service, the results of her steaming will be carefully compared with those of her sister ship, "Caronia," but the builders and owners are convinced that the advantages of the turbine are so pronounced as to leave no room for doubt as to the success of the turbine-driven Cunarders of 25 knots speed, which are now under construction. The "Carmania's" trials were in every way satisfactory. The "Caronia," with the same boiler power, attained a speed of 19½ knots on the measured mile off Skelmorlie. She had been recently docked in order to test her under model conditions. The "Carmania," on the other hand, attained a speed of 20.34 knots, although she had not been docked for the cleaning of her hull since her launch last February. Had her hull received the same attention as that of the "Caronia," she would undoubtedly have made a still better showing.

The record of comparison between the turbine installation of the "Carmania" and the reciprocating-engined "Caronia" will not, of course, be complete until the two vessels have been in service for some time, but the results of the trials of the two ships have convinced the Cunard Company that they were well advised in adopting this new form of propulsion, and no nervousness is felt as to the success of the other two vessels which are now being constructed. The British nation is now definitely committed to the Parsons turbine, since all the ships of this year's naval programme are to be thus fitted, and the triumph of the "Carmania" on her trials and during her maiden cruise has given widespread satisfaction and lifted a load of anxiety from the shoulders of



A "CABINE DE LUXE"

THE PURSER'S OFFICE IS ARRANGED WITH COUNTERS AND KEY BOXES SIMILAR TO THE OFFICE OF A METROPOLITAN HOTEL

A DOUBLE-BERTH STATEROOM

naval authorities. Apart from the gain in speed which the turbine confers, great importance is attached to the absence of vibration and the increase in maneuvring power.

In a man-of-war the saving of weight effected by the adoption of the turbine is also a matter of great importance. Further, the turbine needs less attention and is less liable to develop defects than the reciprocating engine. The comparative simplicity of the working of the turbine has had a good deal to do with the adoption of this new mode of propulsion by the British Admiralty, since the engineer officers of the future, under the system of "common entry" for officers of the executive, engineering, and marine lines may possibly be less expert in the practical work of their profession than those whom they are displacing. This, time alone can show, but meantime the simplicity of the running of the turbine is viewed with unmixed satisfaction in view of the trouble experienced with the quick-running reciprocating engines of some of the newest cruisers of the British fleet.

BETTER METHODS OF COMPENSATION FOR WORKMEN

By George W. Dickie

DURING the past two years I have had much to say when I could get anyone to listen, and have written much when I could get any one to read, on the many phases of the labour problem. If it were not for the vital importance of the questions involved, their solution might be left to whatever chance should provide. The industrial world of to-day is face to face with these problems as never before; each individual industry has its own particular type of labour problem to deal with, and, like all questions that deal with men as well as with material things, moral as well as physical problems are involved.

Into the labour question a great many related problems have been projected which have tended to obscure the atmosphere surrounding the main question. Such related problems as industrial education and the proper housing and proper amusements for working people might be termed the industrial humanities, but whenever they have been put into operation as a means of settling labour troubles, they have signally failed. Workmen resent any attempt to make them the subjects of philanthropy. No matter how carefully it may be disguised, it is usually set down by them as the sugar-coating of a very bitter pill.

What the workman wants is justice, not charity. This is the claim of all leaders of labour organizations. It is asserted that the workman does not get his proper share of the industrial result of his labour. So the question is narrowed down to this, "How shall a man be compensated for his work?" Settle that to his satisfaction, and other matters, such as housing and amusing him, he will attend to himself.

Practically all the struggles between employer and employed center around this question of compensation. The labour unions, representing the employed, are more consistent in their answers to this question than the employers, and what the unions want for their constituents may be safely taken as the desire of the workingman as to the compensation that might be justly demanded for their service. This may be briefly stated as,—

1.—A minimum rate of wages per day that will enable the workman to live in comfort according to the standard of comfort of the community in which he lives.

2.—That minimum rate of wages to be earned by a certain maximum of time expended in the service of the employer, this maximum to be fixed by the trade union to which the workman belongs.

3.—The amount of work done, or the industrial result of the service to be such, that the least competent member of the union can easily accomplish it in the maximum time fixed for a day's work.

This is the expressed purpose of all trade unions and to realize it in every-day practice has been, and still is, the cause of every struggle between the employer and the em-

ployed. If the trade unions could go still further and in some way force the markets of the world to accept the products of their industry at such a price as would enable the employer to pay the daily rate of wages demanded for the industrial result of the day's service, there would no longer be any strife between employed and employer. The struggle would then be between the producer and the consumer. In fact, that struggle has begun now, where an approach to the condition I have named has been brought about, as in the building trades, where the market is local and cannot escape from the local conditions imposed by the unions. If it be granted that the trade unions can control only markets that are strictly local, then industries whose products must compete in the general market can succeed only where the labour cost is not greater than the average labour cost of similar products made elsewhere, but that compete in the same markets. This fact labour unions will not consider, but usually insist that there is a large item of profit out of which these differences can be made good without materially reducing the final profit resulting from the manufacture of the thing in question.

After devoting many years to the study of the problems that lie at the root of what is known as the labour question, I have come, slowly but inevitably, to the conclusion that the present method of settlement between employer and employed for the work performed is entirely wrong, because equity does not form the basis of settlement. There must be a righteous solution for all questions that arise between employer and employed, and I wish at the outset to impress this on the minds of those who desire to interest themselves in the problems involved, for unless these questions are settled righteously, they will remain forever unsolved. The settlement must be right in the eyes of the employer and right in the eyes of the employed.

When either of these two parties have been compelled through force of circumstances to accept a settlement that it considers unjust, the matter is not settled, but only continued until the aggrieved party thinks it is strong enough to again open hostilities. This necessity of being always ready to fight has convinced the workingman that his salvation lies in being organized for that purpose. Hence the trade unions and the workingman's willingness to be handled in mass by these institutions, his own individuality being entirely lost in the process.

This disappearance of the workingman as a distinct personality might be an interesting study, as I think it is quite possible to trace out the methods by which he has ultimately lost himself in the aggregate of some trade union. Such a study would reveal the methods by which he has reached the unfortunate conclusion, which now regulates his conduct, that whoever employs him is his enemy. This fact leads to an almost constant struggle between men who have work to do and the men who want to do it.

This attitude of hostility has removed from the mind of the workingman the interest which he used to feel in his work, as to the quality of it, and whether the quantity produced made it safe for his employer to continue to keep him employed. Where large numbers of men are employed, few of them ever concern themselves as to whether the work done during the day is really worth, and can be sold by the employer for, the wages that are paid for doing it. If the trade unions would insist on their members doing each day an amount of work that would make the employer safe in carrying out his contract obligations, they would pave the way to a better understanding between the employer and employed.

In order that there may be just relationship between the employer and the employed, there must be a just relationship between the work done

by the employed and the money paid for doing it by the employer. How much a man should work and how much he should be paid for the work he does, is the great question around which all the misunderstandings have arisen, resulting in the strife that continually tends to retard industrial progress.

The great majority of mankind must work in order to live. This condition is not likely to change, nor is it desirable that it should change; and, while men keep protesting against this condition of life as an imposition, it is, in the main, not so much against the fact as against the manner in which the burden is imposed. The yoke does not fit and the load is unjustly applied. Hence, the general bitterness of feeling displayed against the employer by the employed springs (whether real or fancied) from a sense of unjust treatment. In the removal of this feeling lies the solution of the problem known as the labour question. This feeling is deep-rooted and much time and great patience will be needed to reach the desired result. Much has been expected from what is known as the humanities in industrial establishments, but the solution will not come through that channel.

The workingman, especially if he be of the right sort, resents being catered to, and, no matter how honest the motive of his employer may be in his efforts to make the surroundings of those who work with him pleasant and cheerful, the men look upon all such efforts with suspicion. Industrial establishments should be made comfortable and even attractive, as far as the operations carried on within them permit, and wise laws should be enacted everywhere to secure proper surroundings and comfortable, safe shelter, suited to the proper prosecution of every industry. But this, even in its most perfect development, cannot have any effect on the solution of this problem.

In what direction, then, must we look for the true balance between these antagonistic forces by which a righteous equilibrium can be maintained and a lasting peace secured?

A careful study of the labour problem will show that there are generally two great points at issue between the employer and the employed over which all their battles are fought,—questions which have become so linked together that it is hardly possible to pull them apart, and yet, as regards work to be done by the employed for the employer, they have really no very intimate connection. These points are "time" and "money."

There is a proverb that "Time is money." That is not true. Time is an opportunity, which, if properly employed, may mean money or something more precious. The workman wants to give little time and get in return much money. The employer, on the other hand, wants to give little money and get in return much time. Between these points of time and money, the real thing that the workmen can do and that the employer wants done, is generally lost sight of. If an hour of time by any workman employed at a given trade always produced the same industrial result, then time and money could be properly treated together; but anyone who has had to deal with them knows very well that the one can never be taken as a just measure of the other.

The majority of employers and employed contend that the labour of a workman is a commodity that can be bought and sold by measure, like any other marketable article, and that its value is to be expressed in so much money per unit of time. In fact, this is the method that usually prevails in buying and selling labour, and, wherever workmen are organized into trade unions, this is the method which they strive to make universal. The workingman who is in the market with his skilled labour for sale is not seeking a purchaser for any tangible amount of work, but what he wants to dispose of is a certain number of hours each day at so much money for each

hour. During these hours the purchaser is to coax the article he desires to purchase out of him, if he can, and this is often quite impossible. In fact, all that the workman sells is an opportunity.

The desire of the purchaser for something more tangible than a bare opportunity has led him to propose piece work instead of time work, which is a more just way of paying for work, and in some trades where the work can be portioned out to the men this method has become the rule. But the workmen, especially where they are organized into unions, generally protest against this method of paying for their work, claiming that in all its varied applications it is simply task work, having always behind it a certain rate of wages kept constantly in view by the employer, who, as soon as any workman, by superior skill or extra diligence, manages to earn more than he thinks a workman's wages should be, begins to cut down the price per piece without regard to what the market values allow him to pay for the work done.

There is, unfortunately, much truth in this argument of the workman against piece work. The employer is not always just in dealing with the workman in regard to the value of the work that is to be done. This arises from the idea of considering time and money together. This wrong idea is in the minds of both parties,—some definite rate of wages per hour or day, that, from the workman's point of view, he should never fail to reach, no matter how small the day's industrial result may be, and that, from his employer's point of view, he should never by any exertion on his part be allowed to exceed, no matter how large the day's industrial result might be.

It is not my intention to indulge in any discussion of the methods by which the trade unions endeavour to perpetuate the time method of recompense for the workmen, nor do I desire in any way to antagonize the unions, as I hope that the time is not far off when the trade unions will advocate the measure which I now propose.

I have for many years been convinced that neither time work nor piece work, as we understand these terms, should be the basis for settlement between the employer and the employed, and as long as these methods with all their opportunities for injustice on both sides prevail, we must go on fighting as we are now doing, each party keenly watching for a chance to outflank the other.

I have faith enough in human nature as we find it in the great body of workingmen and as we find it in those who desire to purchase their labour, to believe that it is possible, and, if honestly set about, quite practicable, to separate the labour cost from the material and all other costs in industrial products, and, for the labour part of the product of any industrial establishment to enter into contract with the men, as a whole, for the performance of the entire labour involved in completing the product ready for the market.

This proposition is not to be confounded with any scheme for the division of the profits of an industrial concern with the workmen. It is simply dividing the responsibility of bringing about the desired result between the capital and the labour employed. Profit is a separate and distinct item in the estimate of cost and has nothing to do with the labour cost, my plan being that after the representatives of the workmen are satisfied that the amount provided in the estimate for labour is correct and a safe amount for the men, as a whole, to undertake the labour for, they shall, on behalf of all the men employed, sign an agreement to do all the labour involved in carrying out the contract in question, for the amount provided.

This requires not only confidence, but experience in regard to labour values on both sides. This quality already exists to a greater extent than is generally known among the

more intelligent workmen, such as those who would be chosen as representatives in such a transaction.

No contract can be safely entered into by any industrial establishment without a careful estimate made of all the component parts that enter into, and, in the aggregate, represent the cost of the completed work to be contracted for.

The estimator, if his work is to be a safe guide for the firm or company that he represents, must have correct information as to the amount and the cost of all materials to be used in carrying out the proposed contract. He must know what proportion of the general expense of the establishment must be charged to the contract. Then the proper or relative value of the proposed contract to the capital of the company and the length of time to complete the work, will enable him to determine the profit that should be added to the estimate. These items, the estimator, if he be a competent man, can determine accurately, but the largest of all the items he has to deal with, that of the cost of labour to convert the crude materials into the thing contracted for, he can only approximate from past experience. What the ultimate cost will be, depends largely upon the relationship between his company and the men who are to do the work.

The variations in the cost of labour on the same amount of work done at different times, resulting from different men and different conditions, are often sufficient to wipe out, several times over, the estimated profit on a contract. My proposition is simply to have the men, as a whole, through their representatives, assume this uncertain part of the contract, because the power lies with them to remove all uncertainty in regard to the final result. In large contracts it is the usual practice to bargain for the costs of all materials before work begins, and it seems to me that it might be quite as possible for the employer to bargain with his workmen, as a whole, for all the labour on any contract. The one party only needs confidence in the justice of the other to make such a method perfectly practicable.

Much of my time for the past thirty years has been devoted to estimating on the cost of work. This estimating has involved labour costs amounting to very large sums in wages each year. In every estimate the cost of labour is a distinct and independent item, which can be readily dealt with apart from all other items in the estimate and which could be taken up with representative workmen who would soon acquire experience in such work. It could be contracted for without in any way involving the other items of the estimate, thus converting the most uncertain part of the estimate into a known, definite amount.

Even under ordinary peaceable conditions in estimates involving many trades and large numbers of men, large allowances must be made for unwilling hands that wait for time to move on to pay day, and who have no interest in what has been produced for the pay they receive.

My experience has led me to the conclusion that a desire to do the very best they could by all hands every day, would, in establishments that pay their men for the time they are at work, practically double the labour result, and with such a possible margin to work on, the employer and the employed might both make a good thing out of it, if each had faith enough in the other to do his best for the good of both.

I have carefully studied several methods in use at industrial establishments on both sides of the Atlantic, having for their object the compensation of their workmen in accordance with the work produced without the objectionable feature of piece work. I refer to the various premium methods that fix the amount of work expected to be done in a given time, and allow a premium or bonus on any work done beyond the

stipulated amount; but most of these plans, like piece work, deal with the product of each individual man, and besides raising comparisons among the men themselves, which are odious, can be applied only to such parts of the work that can readily be separated from the general work being done, and in large establishments, this covers but a small portion of the work.

My experience, combined with a careful study of this subject, has forced me to the conclusion that the only way to get the best result out of all the men employed in a large industrial establishment is to combine them all by mutual interest in bringing about the best possible industrial result. All talk about operating an establishment simply to give employment to workingmen, of which we hear so much and which the workmen never believe, should be stopped and the workingman should be made to understand that the establishment in which he works must be operated at a profit or it must soon be closed.

Many workmen, gathering their information from wild statements made by labour leaders and a certain class of newspapers, have exaggerated notions of the profits made in the industries. I had occasion to speak some time ago to a number of workingmen bent on trying to force very hard conditions on their employers. The question of profit was brought up during the discussion, showing that their ideas of what was possible for their employers to do and yet have something left for profit, were quite remarkable, nor could any impression be made upon them by the statement that in eighteen years their employers had paid out in wages $28,000,000, and during the same time the stockholders had been paid $1,300,000 in profits, or less than 5 per cent. of the wages paid.

These same men, if they all had worked at their best, might have readily doubled the result, and thereby materially increased both pay and profit.

The main thing that both employer and employed must accept as the foundation for any scheme that is to permanently bring about proper and natural relations between them, is justice. Without that nothing can be done, and the one must have perfect confidence in the justice of the other. If this attitude towards each other could be assumed and maintained, all other difficulties could be overcome.

Most of my thinking on these problems has been in connection with industries of a similar character to that in which I am myself engaged (shipbuilding), but wherever I have had complete data in regard to the conditions in other industries, I have found the method of contracting for the labour as a whole with the workmen as a whole, quite practicable.

I will now endeavour to state, as far as I can in words, how I would propose to carry out such a system of compensation for workmen. I have already stated that in all estimates labour is treated as an independent factor, and it is the most difficult of all the factors entering into an estimate to determine. What it should be to meet the market value of the work produced is within the power of the experienced estimator to determine; but what it will be, depends entirely on how the men that are to do it, feel about it.

I have found out a curious fact about the matter of labour values, that all the intelligent workmen whom I consult with about it, set a much lower value on the labour required to produce a certain result than my experience tells me is necessary. They instinctively think of what a man could do if he tried, while I have been forced to figure on what he generally does, and thus what under ordinary circumstances an unwilling hand can be persuaded to do has become the measure of the value of labour in the estimates that are regularly made for contract work.

In the shipbuilding estimates that I make, the labour item runs from 40 per cent. to 60 per cent. of the whole amount. Very few workmen believe this; in fact, I have often found them under the impression that the profit runs from 40 per cent. to 60 per cent.

Suppose then, that an employer agreed with all the men he employed that the amount provided for labour in any estimate should be accepted by them as a whole, as the compensation which they should receive for performing all the labour required to complete the work represented by that estimate. All the men employed, in that case, would have to be represented by a committee of themselves, say one from each department of the works, who would go over the estimate of labour with the manager and accept it on behalf of the men they represent. It might be contended that the men would be largely at the mercy of the representative of the employer who made the estimate, as they would not be competent to check his figures. This is assuming that the representatives of the men would be more or less ignorant of the proper value of labour.

I am convinced, however, from an extended experience with the kind of men that would be chosen by their fellow workmen as their representatives, that their interests would be perfectly safe. Wherever contracts are made now for detached portions of the work, the men who enter into such contracts are fully competent to figure very closely on the work proposed, and experience would come to them with every opportunity to exercise their judgment. The margin for possible profit to the men is so large that an error would have to be very great indeed to mean actual loss to the workmen; the contract being for all the work with all the men, too little allowed for labour in one place would be balanced by a larger allowance in another.

In the concern with which I have been connected for many years,* and which connection was recently severed, efforts have been made to contract with the men for certain parts of the work, certain men contracting for a certain amount of work, each man receiving his regular wages while the work is in progress and dividing the balance, if any, when the work is complete. The superintendent makes his estimate, comparing it with actual cost of similar work; the man representing those who desire to contract also makes his estimate, and then he and the superintendent get together and reconcile any difference between them.

On eighteen pieces of work contracted for in this way the superintendent's labour cost was $10,348.50; the workmen's estimate of labour was $10,552.50, and yet in some of the items there was quite a difference. It will interest the readers of CASSIER'S MAGAZINE if I give the results of several small contracts worked out on this principle. I have not selected these, but give them in the order in which they occurred.†

1.—Superintendent's estimate of labour cost	$303.65
Five men took work. Regular wages paid.	228.07
Dividend	$75.58
2.—Superintendent's estimate of labour cost	$208.60
Two men took this work. Regular wages paid	169.99
Dividend	$38.61
3.—Superintendent's estimate of labour cost	$358.50
Five men took this work. Regular wages paid	236.98
Dividend	$121.52
4.—Superintendent's estimate of labour cost	$21.00
Two men took this work. Wages paid	18.34
Dividend	$2.66
5.—Superintendent's estimate of labour cost	$198.62
Three men took this work. Wages paid	184.95
Dividend	$13.67
6.—Superintendent's estimate of labour cost	$250.70
One man took this work. Wages paid	116.16
Dividend	$134.54
7.—Superintendent's estimate of labour cost	$431.69
Eight men took this work. Wages paid	393.67
Dividend	$38.02

* Mr. Dickie until recently was manager of the Union Iron Works, of San Francisco, the largest shipbuilding establishment on the Pacific Coast of America.—The Editor.

† Mr. Dickie's figures, while representing American values, are symbolical of probable conditions everywhere.—The Editor.

On the seven items given above, on $1,348.07 paid in wages, the men made a profit of 31.5 per cent. On all the work done in this manner I do not find a single case where the wages paid exceeded the estimate, showing how safe such a method is for both parties, and if the whole establishment undertook the labour part of any contract, after proper investigation, the result, as a whole, would be just as good as that shown in the small portions cited for illustration.

The adoption of the whole plan I propose would result in lifting the workmen into a new condition, making them partners in fact in the concern where they work. When values declined, they would stand their share of the reduction necessary to meet the market, and when values advanced, they would get their share of the benefits derived from such a condition. Under the proposed arrangement I would engage all the men just as they are employed under the present system, the foreman rating each man at what he considers him worth per day or hour, with this difference, that each man's rating should be posted up in the shop in which he works, and his fellow workmen, through their committee, should have the right to have his rate reduced or raised if they found that the work that he turned out was not equal to, or was greater than, his time rating. Wages would be paid as at present, according to the rating, and the wages paid on each job or contract would be charged against the amount accepted by the men on such job or contract.

If the employer were, say, a large shipbuilding concern and the contract in question a first-class armoured cruiser, as soon as the committee had signed for the men, the following notice would be posted in each department:—

"The undersigned, on behalf of all the workmen employed by this company, have agreed this day to perform all the labour of every kind required in the execution of a contract between this company, of the first part, and the United States Navy Department, by its Secretary, of the second part, for the construction, according to plans and specifications, of a first-class armoured cruiser of 15,000 tons displacement and 23,000 H. P., for the sum of $1,430,000, payments to be made monthly to the men working on this work at the time rate for each man, the balance on final completion to be credited to the labour surplus account.

Signed,

Peter Robinson, for the draughting department.

John Anderson, for the pattern makers.

James Adamson, for the engine blacksmith shop.

David Wilson, for the machine shop.

Andrew Doble, for the erecting shop.

William Todd, for the shipyard blacksmith shop.

Peter Davidson, for the shipyard construction work.

John Dixon, for the ship joiners and carpenters.

Peter Scott, for all labourers.

William Nichol for the ship painters.

James Grieg, for the marine machinists.

Adolph Peterson, for the coppersmiths and plumbers."

The amount, as stated in this agreement, would be credited on the books to the labour account. All payments made to the men working on the job would be charged against this amount. On completion, the unexpended amount, if any, would be credited to the labour surplus account. If on any job or contract the wages paid should be more than the amount accepted for labour, the difference would be charged to the labour surplus account.

Say at the end of each half year, the amount that had accumulated in the labour surplus account, less a percentage for the guarantee fund, would be available as a dividend on

labour, and whatever per cent. it formed of the total amount paid for labour during the half year would be the percentage which each man would receive on the wages he had earned during this period.

This secures for the workman the total profit on the estimated cost of labour on all work done in the establishment, whether he was a long or short time employed during the half year, and without any reference to the particular job on which he may have worked. No matter what the man may be doing or in what capacity he works, how he does that work will either swell or diminish the general dividend, and every man will see to it that his follow workman does not reduce his dividend, if any instruction on his part will prevent it.

The great advantage of such a method, applied to the labour part of an industrial establishment, is its inherent justice, both to the employer and the employed,—a fixed value for a given amount of work to be done that makes estimating safe, and compensation to all the men according to the amount of work they do as a whole. The men being directly interested in the work, will naturally do their best and will see to it that their fellow workmen do the same.

I believe that the time must soon come when labour must be dealt with in some such way as I have described, not as a marketable article that can be bought by the time-measuring arrangement, but as a living thing that can be contracted with, that has feelings and hopes and something before it to strive for, or it will not strive at all, and whose feelings, hopes, and aspirations must be taken into account in all plans and estimates of cost. I believe that the difference in result between the work of earnest workmen trying to do the best that is in them, and whose recompense is measured by what they accomplish, and the indifferent labour that is forced out of a man by constant watching and urging during a certain number of hours, is so great that only those who have to deal with the problem daily can comprehend its magnitude.

I fully understand that such a system of compensation for workmen as I have outlined presents difficulties of a special character in every kind of business. Yet in some kinds of business where I had hardly hoped such a plan would be successful it is being tried with very good prospects of giving entire satisfaction to all concerned.

After I had read a paper on this subject before the Commonwealth Club of California, a prominent member of that club, at the head of a large drygoods firm, read the paper to the heads of departments in his establishment and they decided to try it in one or two departments, taking the labour cost in the department in proportion to the sales as a basis, and agreeing to pay that proportion of the gross sales to the labour. The result has been good. The wages paid were the same, but the incentive to diligence in hope of a dividend resulted in a better industrial result. At the end of a recent month $1200 were divided in the departments under the experimental system, as a dividend on the month's operations.

The trade unions might use their power over the men to prevent such a system being adopted, as the unions claim that if the men do more work a less number of men will be employed. This fallacy seems to be the most difficult one to combat in dealing with a trade union.

If it were true, that, if a man turns out more work per day than he used to, he is thereby forcing some other man to go without work, then after such a strike as we had in certain trades in San Francisco three years ago, when the men employed did no work at all for ten months, there should have been more men employed after the strike to do the work left undone by the strikers, but this was not the case and never has

been the case in all the history of industrial struggles.

The fact is that the more work is turned out per man in any industry, the more men will be employed in such an industry.

I believe that some such plan as I propose will be ultimately accepted by both employer and employed, as the only just solution for the differences between them. Courage and honesty, combined with the right kind of skill on the part of those managing large industrial concerns, would, if patiently applied, result in such benefits to workmen and to those with whom they work as would save many an industry, which, under the present unjust methods of dealing with labour problems, have nothing before them but impending ruin.

The present conditions that prevail among employers and employed are so unsatisfactory, often manifesting themselves in mutual distrust and hatred of one another, and these conditions are so dangerous to the best interests of society, that some remedy must surely be found before the twentieth century has advanced very far, if our boasted civilization is all that we hope and trust it is. The best intellects of our day have been directed to the solution of the labour problem, and practical men will have to find a better way of dealing with labour than by opposing force with force.

Those who are between the upper and nether millstones in the process of grinding-out an industrial product for the market, between the capitalist and the workmen, feel the difficulties of this problem most. They see daily how little is wrung out of unwilling men for the price paid, and how ineffectual the forcing process is.

Some way must be found that will lead to a condition of willingness on the part of workmen to do the very best they can themselves, and to encourage all their fellow workmen to do their best to promote the general welfare of the establishment in which they earn their living. By so doing, security would be insured to the trade, and their recompense would be what justly belongs to the men who do the work. I have thought of many ways to reach the result aimed at, but any way that I have endeavoured to work out, that did not provide for every man's compensation being according to the amount of work done, has led me into entanglements quite as bad as those that now prevail.

In every industrial product, where material is worked up into marketable form, a certain part of the cost of doing so is available for compensation to the men whose work has changed the materials into the desired form, and that part justly belongs to the workmen. By present methods this part, sometimes less and often very much more, is divided among the men whose time is charged to the work according to the amount of time consumed, instead of according to the result accomplished. In other words, the cost of work depends upon the condition of willingness or unwillingness of the workers, whereas the cost of work should be a definite and known amount, and the workman's share of that amount should depend on his willingness or unwillingness to work.

I trust that in presenting this subject I have made myself clear. I have tried to do so. The subject is a difficult one. In no way do I intend to strike at unionism. If such a system as I propose should become the method of compensation for labour, the labour unions might, under certain conditions, represent the workman's side of the contract. My aim is to bring industrial peace and save industries that now have but a poor chance to live.

SOME NOTABLE AMERICAN RAILWAY BRIDGES

By James G. Walton

MASSIVE steel bridges are now so numerous that additions to their number must be of special note before they are considered of sufficient interest for general description; but the bridges described in this article stand out among those recently erected for railway purposes as remarkable examples of the art of steel bridge building as practiced in the United States.

All the bridges described were built by the same firm, the American Bridge Company, one crossing the Mississippi River at Thebes, Ill.; the second spanning the Monongahela River at Pittsburg, Pa., and the third of a type similar to the second, crossing the Ohio River at Mingo Island near Pittsburg. Figs. 5 and 6 show the Thebes bridge, and the illustrations give a good idea of its mas-

FIG. 1.—LOOKING ACROSS THE CANTILEVER BRIDGE OVER THE MONONGAHELA RIVER AT PITTSBURG, PA.

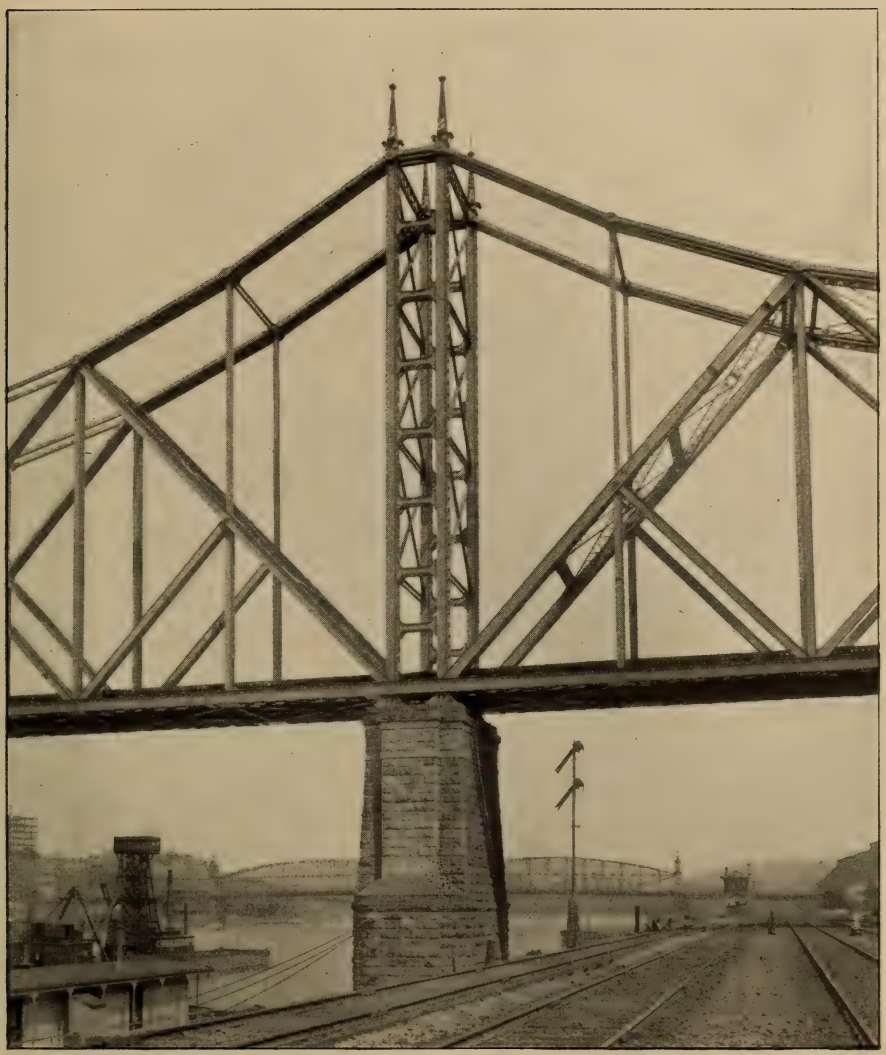


FIG. 2.—A TOWER OF THE MONONGAHELA RIVER BRIDGE

sive proportions. This bridge was erected to supersede the car ferries previously employed for connecting the Illinois Central, Chicago & Eastern Illinois, and St. Louis & Southwestern Railroads on the one bank of the river, and the "'Frisco" system, Iron Mountain, and St. Louis Southern Railways on the other bank, thus saving much time necessarily wasted in transit, and allowing traffic at times when navigation is interfered with by ice and floods. The river is 2700 feet wide at high water, and 50 feet deep at low water, so that a bridge having several spans was absolutely necessary, but it had to be designed to allow at least 650 feet clear waterway at the centre, with waterways at the sides of at least 500 feet, the clear height above high water level being 65 feet.

The completed bridge measures 2750 feet between the end piers, and the distances between the various piers from centre to centre are reck-

FIG. 3.—THE CANTILEVER BRIDGE OVER THE MONONGAHELA RIVER AT PITTSBURG, PA., CARRIES THE PITTSBURG, CARNEGIE & WESTERN RAILROAD ACROSS THE HARBOUR OR "POOL" OF PITTSBURG

FIG. 4.—THE BRIDGE OVER THE OHIO RIVER AT MINGO ISLAND, OHIO, IS ALSO FOR THE PITTSBURG, CARNEGIE & WESTERN RAILROAD. SEE PAGE 207

oned from either end, 518 feet, 521 feet, 671 feet, 521 feet, and 518 feet. The second and fourth spans are fixed and are formed with cantilever arms at each end, each 152 feet, 6 inches in length. The end sections are supported at one end by a pier and at the other end by a cantilever arm. The central suspended span is carried at both ends by cantilever arms of the same design and length, 366 feet. At each end the line is carried by concrete arch viaducts extending across the level river banks for about 600 feet, to earth embankments. The construction of these viaducts was included in the bridge contract.

The entire superstructure is of medium steel, having an elastic limit of 37,000 pounds or more, and an ultimate strength of 62,000 to 70,000 pounds per square inch. The cantilever design was adopted partly for economy, but principally because the bridge could then be constructed without blocking the waterway by a construction staging, as would have been otherwise necessary. The various members are constructed of continuous pin-connected trusses, spaced 32 feet apart on centres and giving a train clearance horizontally of 27 feet 8 inches, and a vertical clearance of 22 feet 6 inches. Each section consists of a system of rigid X-bracing on top and bottom chords, with sway bracing transversely. The two fixed spans weigh 11,560 pounds per lineal foot, and the corresponding weights of the suspended and cantilever spans are 7720 and 11,650 pounds, respectively. The piers are built on solid rock foundations with pneumatic caisson footings.

This bridge is one of the largest having several spans across the Mississippi River or in America, and the central span of 671 feet is claimed to be the longest trussed span, not an arch, with two or three exceptions only, in the world.

The following statistics as to cost will be of interest:—Steel superstructure (26,800,000 pounds steel), $140,-

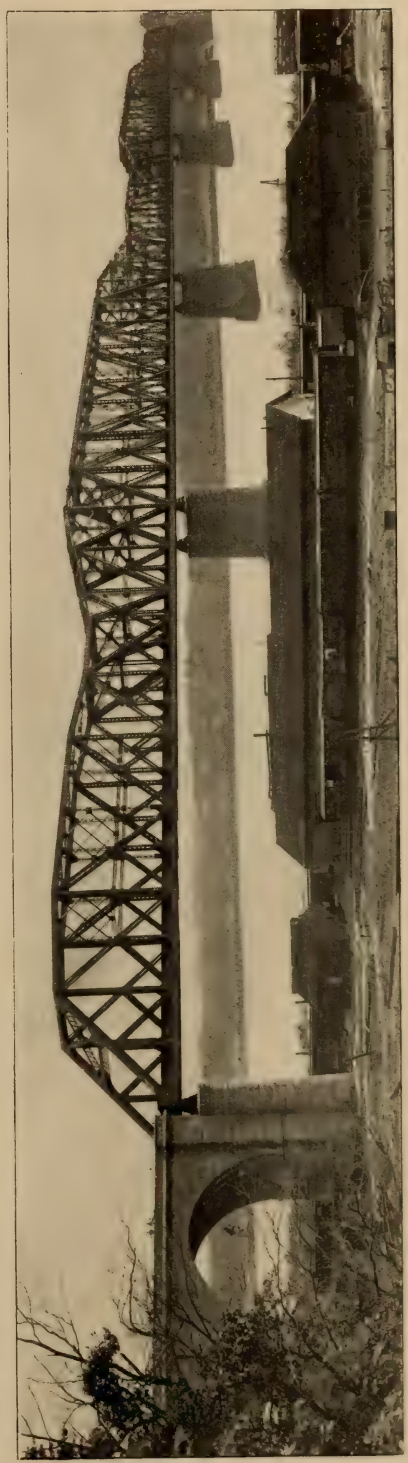


FIG. 5.—THE THEBES CANTILEVER BRIDGE IS ONE OF THE LARGEST ACROSS THE MISSISSIPPI OR IN AMERICA

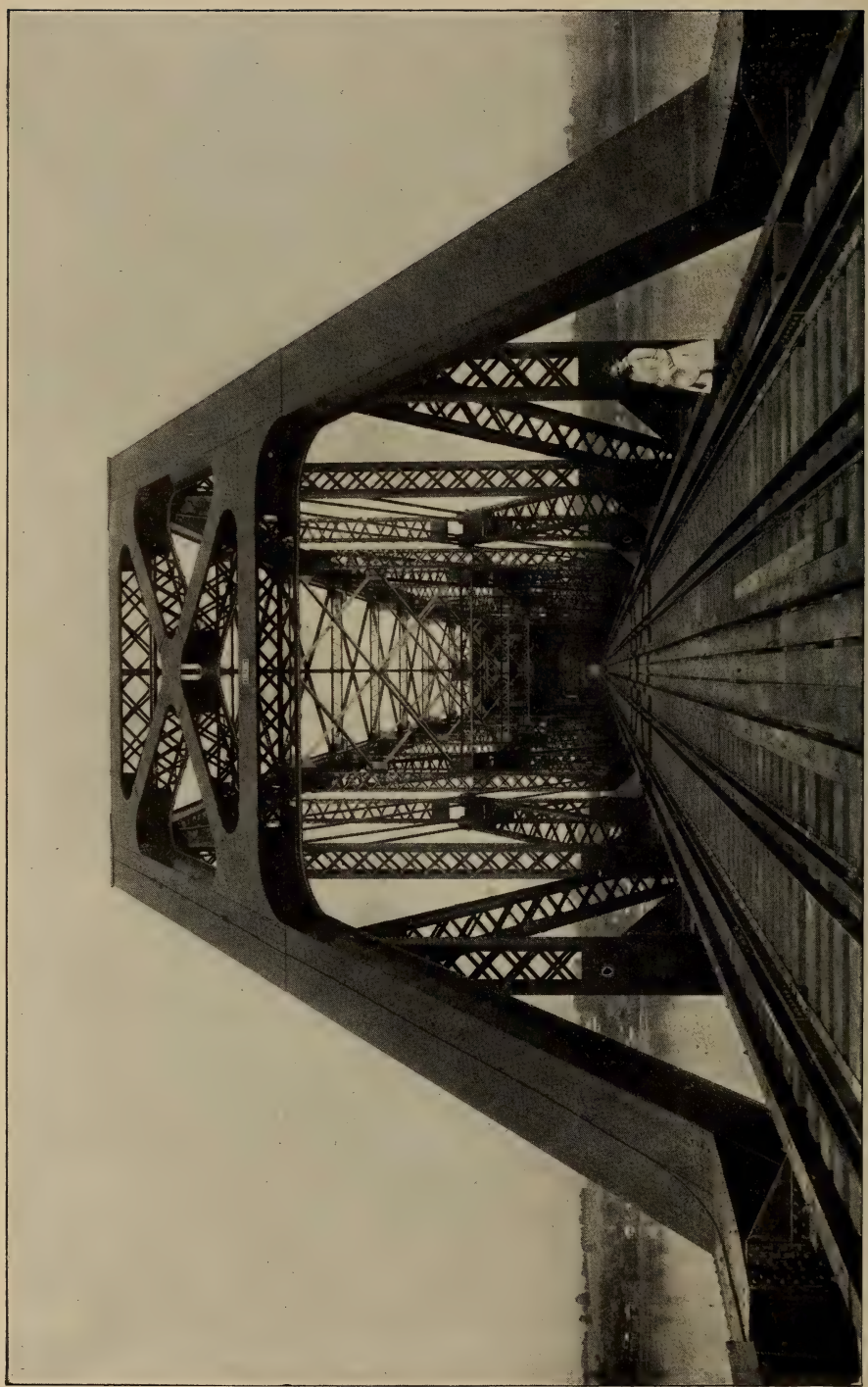


FIG. 6.—LOOKING ACROSS THE FIVE-SPAN CANTILEVER BRIDGE OVER THE MISSISSIPPI RIVER AT THEBES, ILL.

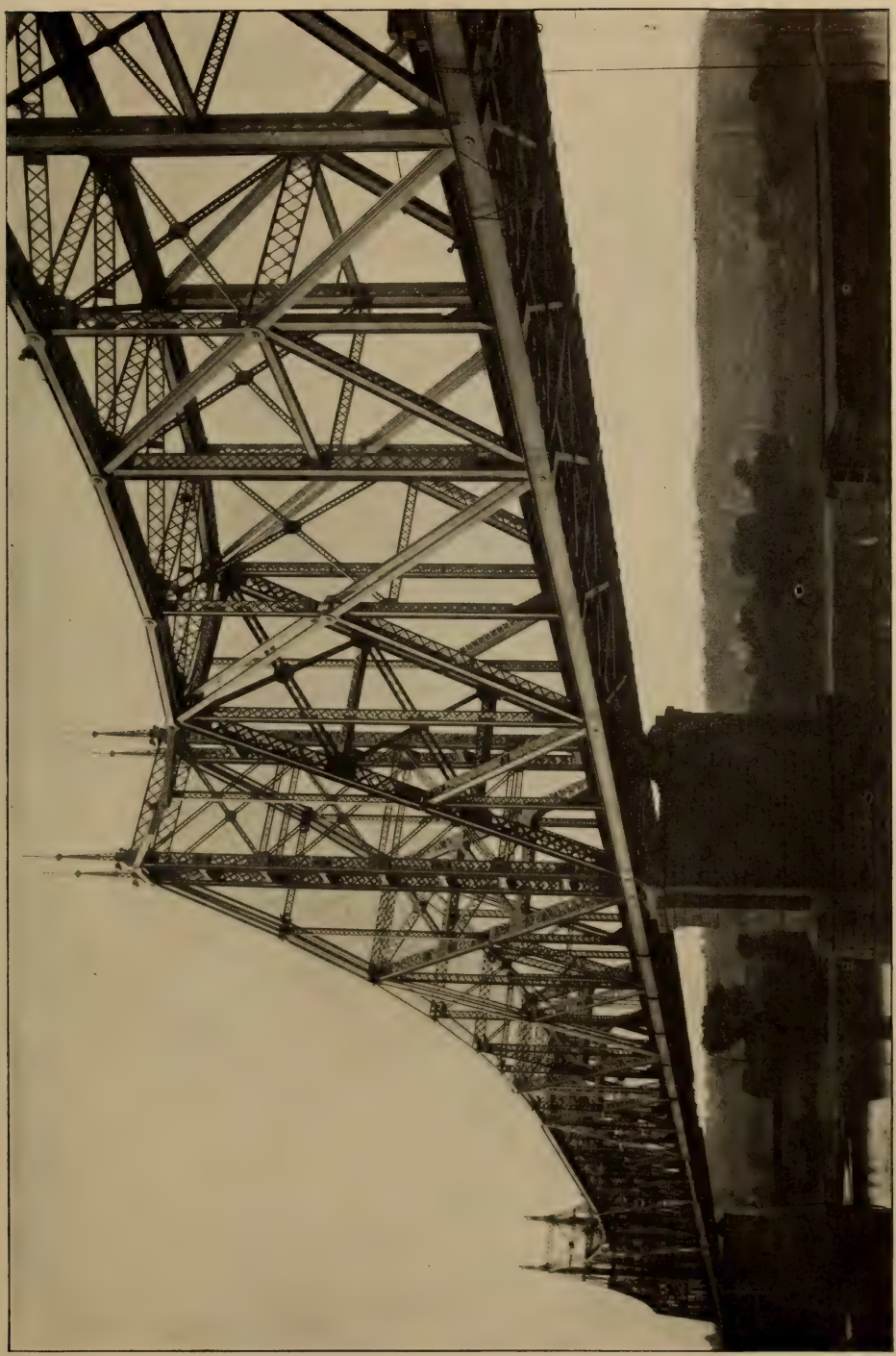


FIG 7.—A CLOSER VIEW OF THE BRIDGE OVER THE OHIO RIVER AT MINGO ISLAND

000; piers and foundations, $600,000; concrete arch viaducts,etc., $300,000; total cost, $2,800,000.

Figs. 1, 2, and 3 illustrate the Monongahela bridge. It carries the Pittsburg, Carnegie & Western section of the Wabash system across the harbour or "pool" of Pittsburg, and its location necessitated a single span of over 800 feet and a clearance height of 70 feet at high water. This bridge is claimed to be the heaviest per lineal foot in the world, and comprises two shore anchor spans 346 feet long, carrying cantilever arms 220 feet long, which support a suspended section 360 feet long. The main piers are 812 feet between centres, with a waterway of 786 feet between the foundations. The total length of the bridge is 1504 feet. The line of the bridge is on a 1-in-100 grade, and consequently the level at one end is 80 feet above low water, and at the other end it is 87 feet 9 inches. The towers are 126 feet 6 inches above the piers, and the panels of the centre span are 60 feet high. On each side of the towers are four panels 40 feet wide, the others being 30 feet wide. The girders are spaced 31 feet between centres. The foundations are carried down to a slate-rock bed.

A further idea of the massive construction of this bridge may be had from the knowledge that 14-inch eyebars and 12-inch pins are used. The builders contracted to erect the bridge within four months from the completion of the foundations and masonry, and it is believed that this time was not exceeded.

The bridge shown in Figs. 4 and 7 is of similar type and design to that just described, but is somewhat smaller, though it is still a notable example of American bridge building. It is traversed by the same railway as is the Monongahela bridge,—in fact, both were necessitated by the building of a new section of railway, and they were built simultaneously. The anchor spans are 298 feet long, the cantilever arms, 194 feet 9 inches long, and the suspended section is 319 feet 6 inches long, the total length being 1296 feet 6 inches.

The writer is indebted to the American Bridge Company for the interesting photographs reproduced, and for the foregoing particulars.

FIRE HAZARDS AND HOW TO AVOID THEM

By Washington Devereux, Inspector for the Philadelphia Fire Underwriters' Association

NOTHING is absolutely fireproof. There are, however, slow-burning structures, or in other words, structures that will withstand intense heat. Of these, may be mentioned buildings with protected steel frames, hollow tile, hollow concrete blocks, brick construction, hollow metal window and door frames, and wired glass in skylights, windows, and doors; there are also to be considered metallic furniture, such as desks, chairs, filing cabinets, book cases, clothes lockers, etc., standard automatic fire doors, so protected as to avoid the possibility of non-operation in the event of fire, automatic sprinklers inside and outside of building, outside connections which will enable the fire department to connect directly with the interior as well as with the exterior sprinkler system, sprinklers on roof, fire hydrants on roof, chemical fire extinguishers, and standpipes equipped with hose that will not kink when drawn from a reel or rack. In buildings of large areas, there should be substantial inside fire walls, dividing the building into smaller areas, equipped with standard fire doors which automatically cut off the section of the building in which a fire may originate.

High-pressure water systems have their use, to be sure, but water damage is in some instances far greater than the fire damage; furthermore, in a building over six floors in height, it is difficult to tell just what effect the water is having on a fire.

The modern pumping station capable of discharging from 9100 to 11,000 gallons of water per minute will surely tax the skill, ingenuity, and good judgment of the best fire engineer. To extinguish a fire with as little water damage as possible is, or should be, the pride of all firemen.

A large amount of combustible material in the shape of mercandise within a building is sufficient to tax to the utmost the most modern fire-resisting construction. In a building of this class, however, a fire can more readily be held where it originates, so that the possibility of spreading is reduced, by avoidance of communication with adjoining or nearby properties.

Insufficient water supply has been the cause many times of fires gaining great headway, in fact, getting beyond the control of the local fire department; frozen hydrants, of which there are thousands every winter in all the larger cities, are also responsible for the spread of fires, and this is especially true in towns where the water works are controlled by private corporations. General indifference to the public fire protection is quite marked among many of these corporations.

Defective fire-alarm systems have caused many serious delays in sending out an alarm of fire. Boxes that do not record properly, weak batteries, defective joints, poor connections in the various circuits, and leakages all tend to weaken and destroy the efficiency of a fire-alarm system.

The efficiency of a fire department, —public, private, or volunteer,—is entirely dependent upon its equipment, water supply, and the executive ability of its officers. Lack of knowledge regarding the conditions which a fire department must encounter, many times calls forth harsh and ignorant criticisms.

A fire once having gained head-

way will create a frightful draught, and often the heat will become sufficiently great to ignite a structure of average build on the weather side of the flames, at a distance of more than a hundred feet. Atmospheric conditions also influence fires to a very large degree. Owing to this cause, a fire may burn more fiercely on a calm day in January than during a blustering day in February.

The laws regarding the storage and handling of goods liable to cause fires are quite expansive and most liberal, to the detriment of those most affected. The too frequent accidents from gross carelessness or lack of knowledge of the hazard involved, surely are worthy of official consideration.

Materials of a hazardous nature must be transported, but the methods employed could be greatly improved to the safety of the public, and the progress of the arts and sciences would not be affected in the least. Chemicals, non-combustible themselves, but which, when mixed, will cause explosion and fire, should never be stored in the same car, nor in close proximity to one another in warehouses. Muriatic, sulphuric, carbolic, nitric, picric, iodic, chromic, and chloric acids are stored and transported in glass receptacles; they are not compatible with organic matter, but the breaking of two or more vessels is sure to cause a fire. The fumes of these acids are dangerous to life in many instances.

Carbolic acid, used in homes, factories, shops, and offices as a germ destroyer, should not be brought into the presence of an open flame, as the vapour is inflammable and under certain conditions an explosion may occur. The expansive and explosive properties of carbolic acid gas were well demonstrated recently in a hospital, in which an attendant attempted to liquefy some carbolic acid crystals without due regard to the rapid expansion which would follow the close contact of the crystals when exposed to abnormal heat. An explosion followed, painfully wounding the experimenter.

Picric acid, sodium, and potash, extensively used in dyeing establishments and pyrotechnic manufacture, are explosives of high degree. These mixtures are often handled by persons who have no knowledge of the hazard involved.

As a matter of fact, in all classes of manufacture where chemicals are employed, there is an element of danger which could be greatly reduced by an intelligent explanation and careful supervision of the ingredients employed. The proper storage of highly combustible materials is a matter of little or no thought to the average wholesale or retail manufacturer or dealer.

The great fire which destroyed nearly the whole of Baltimore, Maryland, last year would not have occurred but for an unusual amount of celluloid goods stored on the premises where the fire originated. The fire having gained headway, the intense heat caused the celluloid to ignite, filling the building with dense volumes of smoke, impregnated with carbon monoxide, and upon the arrival of the firemen the building was "opened up," admitting the necessary amount of fresh air to form an explosive mixture. The explosion which immediately followed the admission of fresh air, cast fire brands in all directions.

An establishment directly opposite, carrying a line of sportsman's goods, along with a quantity of gun-powder, was one of the first buildings to ignite. The explosion of the gunpowder tossed fire brands and burning timbers among surrounding properties, a pyrotechnic manufacturing establishment nearby was soon in flames, and the explosion of the contents, such as skyrockets, mines, Roman-candles, and articles of similar explosive character, were shot in all directions.

These fell on many of the roofs of buildings, and ignited the shingles, the prevailing form of roof covering

in the city of Baltimore on the memorable Sunday of February 7, 1904. Many of the rockets entered unoccupied buildings, starting fires which were not discovered until well advanced.

Celluloid toilet articles, such as hair brushes, match cases, cigar holders, pipe stems, lamp shades, are made by subjecting gun-cotton and camphor to hydraulic pressure; this composition is very combustible, igniting at a low temperature of 290 degrees to 300 degrees F.

In the storage of chemicals, conditions may, and do, arise of a most hazardous nature. A chemical by itself may be reasonably or even perfectly safe, but by leakage through crevices, boxes, barrels, and bags containing non-compatible mixtures, an explosive mixture may be formed that will quickly present a dangerous condition. The transit of chemicals should be supervised by an expert analytical chemist.

The possible danger from chemicals that are frequently used in the household is to the general public a matter of grave import. Benzine is a most volatile fluid, readily evaporating when exposed to the air, thus forming a powerful explosive. Benzine is often used to remove stain and grease spots from carpets, clothing, furniture, and as a moth destroyer,—and often, too, with serious results. A short time ago three ladies, in an effort to mothproof the household furniture, sprinkled benzine over the carpets and furniture. The vapour, being heavier than the surrounding atmosphere, was drawn by the draught to the kitchen stove in which was a slow fire. A terrific explosion immediately followed, blowing out the front wall of the building, killing two of the ladies, and seriously injuring the third.

Lacquer used for the purpose of brightening picture frames, gas fixtures, gas radiators, stoves, and metal work in general is a composition of soluble gun-cotton, acetate of amyli and benzine. The use of this substance should be avoided even under the most favourable circumstances, and especially so if there is an open flame within 60 or 75 feet. All furniture polish contains hidden dangers; fires and explosions frequently follow their use. Linseed oil, shellac, hydrochloric acid, butter of antimony and alcohol form the better grade, while the cheaper grade is invariably composed of linseed oil and benzine, or turpentine.

A silk or woolen cloth, saturated with furniture polish and vigourously drawn back and forth over a surface, will generate heat,—the result of friction. Sometimes an electric spark is produced. The gases created by the polish may be ignited by the spark and cause fire.

If one cares to prove this theory, a practicable demonstration can readily be made by taking two pieces of silk,—a half yard each,—fasten them upon two strips of wood, enter a dark room, or closet, and rub the two pieces of silk rapidly together. A shower of electric sparks will quickly follow, and if the air in the room is very dry, the experimenter will experience distinct shocks as from a spark coil; no ill effect, however, will follow the experiment.

Electric sparking, caused by friction, will readily ignite any volatile vapour. A system of electric gas lighting is a practicable demonstration of gas ignition by electric spark. A person rapidly walking over a carpet or rug of high grade, and immediately touching a gas bracket or water spigot, will frequently experience a severe electric shock. If the gas cock is open and the gas flowing, one may readily ignite the gas by placing his finger in direct contact with the tip of the burner. A moment's pause, however, and the experiment will be a failure.

When electric conductors for light and power purposes were first laid underground, a number of persons notified the insurance offices of their great dread of electricity, as they had experienced severe shocks when

touching any metallic substance about the house which had an earth connection. Their firm belief was that leakage from the underground conductors was responsible for this. The real cause, however, was frictional electricity, as already stated.

Oil-cloth factories, printing offices, and cleaning and dyeing establishments use benzine in large quantities. Precautionary measures are, however, used in these to reduce frictional sparking to a minimum. The machines, presses, tanks, and pots containing the benzine are connected to earth by means of heavy copper wires, electrically and mechanically secured to the water pipes. By this means the electricity is carried to the damp earth and dissipated. While this method affords a certain amount of security, accidental fires due to frictional sparking are not infrequent in this class of risks.

In addition to furniture polish and lacquers, there are many other chemical preparations, the use of which in households particularly is attended with fire danger. Liniments composed of oil of turpentine, sulphuric ether chloroform, spirits of camphor, and alcohol are volatile and dangerous to handle. All usual liniments contain two or more of the above ingredients. Equally hazardous are some preparations of "vermin exterminators," "liquid corn cures," and sign and stove polish, etc.

A short time since a young woman in Philadelphia was severely burned while applying stove polish to a hot stove. While applying the polish an explosion occurred, hurling a shower of cinders upon the girl. Firing of the dwelling quickly followed, which required the services of the city fire department. Benzine formed the basis of the stove polish.

Non-explosive benzine, gasoline, or any natural volatile liquid is a farce. The mixing of wintergreen, or other odourous matter with volatile liquids, with a view of deceiving the public, is a practice not uncommon. To ascertain if the liquid is explosive, secure a small can,—an empty baking powder can, for instance,—place in the can the head of an unused match, at the same time introducing a single drop of the liquid under test. Place the cover on the can and hold the latter over an open flame, bottom down. If the mixture is explosive the cover will be blown off upon the ignition of the match head. Be sure, however, that the bulk of liquid from which the sample is taken is removed to a safe distance.

The ever-convenient candle has been the cause of many fires. Before candles are lighted they should be mounted in a metal candlestick; omitting this precaution has led to many serious fires. Mechanics in dimly lighted or dark places invariable use candles as a source of illumination.

Many times the lighted candles are placed upon combustible materials, or mounted on several nails partially driven into woodwork. Not infrequent are the instances where the mechanics fail to extinguish the lighted candle, upon completion of their task, or on leaving the premises at noon. The lighted candle thus employed slowly burns away and finally ignites combustible material nearby; sometimes, too, it may drop from its original position and find lodgement in shavings, excelsior, burlap, and the like.

The careless disposal of lighted cigars, cigarettes, and pipes loaded with lighted tobacco, in waste baskets, among shavings, excelsior, in corners, on mantels, sideboards, pianos, dressing tables, window ledges, wooden chairs, in pigeon-holes of desks, and drawers of work benches, is another fruitful cause of fires. The practice of smoking in bed or while reclining on a couch involves a danger to the smoker which would rob him of the pleasure if he but knew the many serious accidents which have resulted from this indulgence. The smoker often falls asleep and the lighted cigar, cigarette, or the burning tobacco from the pipe bowl

is dropped upon surrounding readily combustible material.

Many times a couch which is supposed to be filled with pure curled hair is filled with excelsior, sponge straw, and a thin layer of curled hair spread on top; such material burns fiercely when once ignited.

Wooden frame sawdust-filled cuspidors are responsible for many fires. Factories, mills, printing offices, mercantile houses, warehouses, in fact, institutions of many kinds, religiously cling to the sawdust cuspidor, though their use is strictly prohibited by fire insurance regulations and fire inspection bureaus. A metal box, partially filled with sand or water is far more sanitary and the hazard is reduced to a minimum.

Fire in a sawdust cuspidor is not perceptible for some time, as it is not attended with a flame at the beginning. Slowly the fine particles of sawdust are carbonized until the sawdust assumes the condition of a hot coal. The course of fire is always downward, finally burning through the box. Should the cuspidor rest on a wooden floor a fire is most likely to occur, especially if the ceiling below the floor is lined or covered with wooden lathes. The lighter woodwork would readily fire, and fanned by the draught between the joists would gain headway of no small proportion before discovered.

The extensive use of sawdust as an oil absorbent in mills, factories, workshops, and warehouses is a common practice,—very hazardous, however, and should not be permitted. Spontaneous combustion is not infrequent from this source of fire. This is particularly true of warehouses where chemicals are stored. Sawdust and chlorate of soda would burst into flame at once if a drop of sulphuric acid (which may be stored nearby and may be slowly oozing from a cracked glass vessel) were to touch the mixture. Many other combinations of salts and sawdust give similar results.

Railway collisions are often the causes of fire. The heating of cars either by steam or electricity and the complete removal of the once much used coal stoves would greatly improve present conditions by reducing the fire hazard. The practice of employing more or less flimsy and inflammable coaches instead of the more costly, but far safer all-steel cars, is still prevalent in a majority of instances, and affords ready fuel to a fire once started.

Heating apparatus of all kinds possesses an element of fire danger which should be considered in its introduction. The average builder and mechanic is slow to believe in the fire danger of hot steam and water pipes, and few will concede the possibility of fire from hot air furnaces and pipes connected with them. Lack of knowledge regarding the hazard involved has resulted in numerous fires from the careless fixing of hearth stones, chimney jambs, and wainscot near fires and stoves (particularly in households, hotels, and apartment houses), or from continued dry heat from steam and hot-water apparatus. The adjoining timber is in time reduced to the state of charcoal,—a condition most favourable to spontaneous combustion.

Steam and hot-water pipes, also hot-air pipes, where they pass through floors, hollow partitions, etc., should be protected by means of metal collars, for the entire length of the combustible material through which they pass. An air space of 1 inch at least should be allowed surrounding the pipe, thus affording free ventilation.

All stovepipes should be telescope one into the other, at least 3 inches, and should be well supported by means of two or more strands of steel wire at each joint in the pipe. At least two registers of hot-air furnaces should be securely fastened "open," especially if the hot-air pipes have short leads. A brisk fire in the furnace and all registers closed, the possibilities of heating the pipes to a dangerous degree is apparent.

The same precaution should be ap-

plied to coal stoves, with the additional precaution of mounting the stove on a square sheet of metal sufficiently large to catch hot coals which may accidently fall from the stove. Or the stove should be mounted on brick or stone work, an air space of 6 inches intervening between the ash pit and the material upon which the stove is mounted.

A proper ash receptacle should be provided,—consisting of a metal can which will hold two days' refuse, the can to be mounted on metal legs at least 6 inches long and well braced by means of metal strips on the outside of the can. All ashes should be removed from the building daily. Wooden receptacles, such as boxes and barrels, should never be used as ash receivers. The practice is usual, however, with many people, especially in large residential districts, and many fires have been traced to hot ashes thrown into such receptacles. The practice among the better grade of buildings is fortunately fast disappearing because of the more modern method of heating, by low-pressure steam and hot-water systems, which, when properly installed, are the safest sources of artificial heat.

The use of rubber hose attached to gas stoves, gas radiators, and drop lamps is a common and hazardous practice. The hose becoming slightly heated near the consuming device, loses its elasticity, permitting a small quantity of gas to escape; the escaping gas is readily ignited by the flame of the consuming device and the rubber hose is soon ablaze. The best grade of rubber hose does not contain more than 15 per cent. of pure Para gum. The intermediate grades have from 3 to 7 per cent. The cheaper grades of flexible gas hose are made of tar, pitch, and a resinous substance smeared on a tightly woven cotton cloth and then formed into a hose; the outer surface is covered with a low grade of cotton material.

Small gas stoves mounted on tables and work-benches, for the heating of irons or cooking purposes, have caused many fires. When the irons or cooking utensils are placed on a lighted gas stove, a greater portion of the heat is forced downward, the table beneath is slowly carbonized, and a fire is most apt to follow. Many persons line the tables with asbestos, tin, or similar fire retardant, believing they have removed the fire danger. While it is true that asbestos and tin will not burn, they will transmit heat and set fire to the woodwork which they are intended to protect.

The space directly under gas stoves should be cut out and replaced with a metal pan to catch sparks. Wherever possible, a stiff iron pipe should be used in making connections from the point of supply to the gas-consuming device. The supply should also be controlled by means of a cock at the point of intersection of the connecting pipes. The hot-water gas heater has less fire hazard, as the apparatus is always installed by a skilled artisan, and is permanent, securely erected, and connected by means of standard metal gas piping.

An unguarded open gas flame within a building is always a menace to life and property. Swinging gas brackets are ill-advised. The possible blowing out of a lava tip must ever be taken into consideration. Open gas flames beneath woodwork, if within 3 feet, should be protected by means of sheet metal curved downward, allowing an air space of at least 3 inches. There are cases of leakage of illuminating gas with resulting fire due to a small hole in the lead pipe at the meter especially. A search being made for the leak with a lighted taper, candle or match, the escaping gas becomes ignited, but produces so small a flame as to be unnoticed. It continues to burn, and the constant heat causes the lead pipe to melt, shooting forth the flame and igniting surrounding combustible material. Many fires originating in basements and cellars and classed as

mysterious may be traced to this cause.

The use of oil-fed lamps, stoves, and lanterns as sources of light and heat have been the cause of a great number of fires, and the casualties resulting therefrom have been greater than those caused by any other one fire hazard.

An oil lamp or stove carrying loose oil is more liable to explode when one-third filled than when the vessel is fully loaded; or a lamp or stove burning low, is more apt to explode than when burning full. When the vessel is well filled there is small chance for gas formation in the tank; but as the oil is consumed, gas forms. The nearer the flame is to the base of the burner, the greater will be the quantity of the gas generated. The least agitation may cause an explosion, and fire follows. Glass oil reservoirs are especially dangerous. The dropping of a lighted lamp, breaking of the tank, and spreading of the oil have brought desolation into many homes.

The Grocers' Exchange, of London, have offered a prize of 120 pounds sterling, which for the last three years has gone begging. It is to go to the inventor of the best-constructed safety lamp in which mineral oil can be burned, the chief merit of which must be absolute safety. The reason for this prize offer is the fact that the number of accidents resulting from the upsetting of mineral oil lamps in the United Kingdom has been enormous and thousands of deaths have been caused by such accidents. In London alone, during 1901, there were 3000 accidents, more or less serious, due to defective mineral oil-burning lamps, stoves, and lanterns.

Matches have also been the causes of many fires. Metal receptacles, preferably with automatic closing covers, should be employed as match safes. The practice of keeping matches in paper boxes, on shelves, tables, benches, and in desk and bureau drawers is most unwise. A fire was caused by the breeze through an open window blowing a paper match box from the dressing table to the floor, where the matches had ignited from friction. Matches have been fired by the sun rays being focused upon them through a blister in a sheet of glass set in a window sash. The phosphorus mixtures all ignite in a mass at a comparatively low temperature, in the majority of cases not exceeding 110 degrees to 130 degrees F.

The potash mixtures (coloured fires) ignite at black heat at a temperature of about 900 degrees F. Notwithstanding the difference in the igniting point of the two preparations, the potash mixtures are the most dangerous of the two, and more than one instance has occurred of their having ignited at ordinary temperatures, spontaneously. The numerous compounds of phosphorus and arsenic, sold under various names as poisons for rats and mice, are answerable for many of the mysterious fires occuring in private dwellings, hotels, offices, warehouses, factories, etc. No sane man would think of leaving ordinary phosphorus loose in rat holes among combustible refuse, but this is just what is being unconsciously done daily. Rats are very fond of phosphorus, which is quite sweet; they are also very fond of warmth. When we consider that they penetrate into the innermost recesses of buildings, it will be seen how dangerous this phosphorus may become, whether in the shape of matches or rat poison, when nibbled at in the soft, fluffy nests formed in innumerable places behind and between dry woodwork, in hollow partitions, near steam pipes, hot-air pipes, and hot-water pipes.

In one instance a family of sparrows was blamed for having caused a fire. An unused match formed part of the nest-building material, located under the wooden cornice of an enclosed porch. Perhaps in cutting the stick to the proper size with its bill, one of the sparrows ignited

the match. However the nest was soon ablaze, setting fire to the surrounding woodwork, which required the services of the fire department to extinguish.

Explosions of dust containing organic matter have caused numerous fires, in many instances wrecking an entire plant. Accidental in some, gross carelessness in other instances is quite manifest. A short time since an explosion of dust and flour in a fur tannery resulted in serious injury to four men. The dust was used in revolving drums for cleaning the skins, and the explosion was caused by one of the workmen holding a lighted candle near one of the drums while it was in motion.

All organic substances in a finely divided state become explosive. Sugar dust, dust in textile mills, sawdust, the dust of rice, spice, niter, sulphur, flour, malt, and grain mills. Coal dust is explosive and highly inflammable. Dust in tanneries, fur factories, paper mills. In fact, any organic or vegetable dust is liable to explode under favourable conditions.

Finely divided substances are not only acted upon more rapidly chemically, but also mechanically, than when in bulk; if, therefore, a substance is capable of uniting with oxygen when in the crude state, it will unite with oxygen with greater avidity when in a state of fine subdivision.

Dust explosions are caused by an organic substance becoming so finely divided that it may be ignited by a spark or flame, causing the rapid formation of gases of many hundred times the volume of the original dust. The tremendous, suddenly applied pressure causes the phenomenal force of those explosions so frequently experienced in flour and malt mills, candy factories, etc. This pressure is increased by the heat generated by the combustion.

The questions to be determined for every kind of dust are,—at what degree of humidity will it cease to explode, how finely divided must each kind of dust be in order to explode, and what is the temperature at the time of explosion?

The amount of moisture present in the atmosphere, or in the dust itself, has an important influence on the causes of dust explosion. A certain degree of humidity for each kind of dust may be reached at which ignition or explosion is impossible. In the more modern mills exhaust pipes are installed, and when properly operated, greatly reduce the fire hazard.

Every year, timber land of great value is destroyed by fire. Some overt act on the part of a "tramp" or other individual equally if not more guilty, starts a fire, and its magnitude depends entirely upon a kind Providence.

Few consider the possible devastation which a piece of oily waste, thrown or accidentally dropped from a railway engine or car, may cause; yet it is not an uncommon occurrence to notice burning brush, grass, and waste along steam railway lines. "Back firing" is the usual method of extinguishing forest fires. The process, however, means needless destruction of valuable property, and is not always effective.

Electricity has proven a fire hazard requiring the serious consideration of those most affected. Fires of electrical origin are not infrequent, due to carelessness, unforeseen circumstances or defective installation. Where repeated blowing of fuses has occurred, the porcelain surface of the fuse block is often covered with a layer of metallic substance, which becomes a partial conductor. Upon the repetition of this blowing, an arc may be formed and maintained by this metallic layer, sometimes fusing and breaking the porcelain cover.

In other cases, particularly slate switch and distributing boards, the melting and resulting arcing have been known to crack the insulating substance and cause short-circuits. The throwing out of sparks from arc

lamps and the dropping of hot carbons have been known to cause fires. Sparks from the commutators of motors; from the short-circuiting of flexible cord (which may be considered one of the weak points of electrical installations), and of fixture wires; from the short-circuiting of cables in conduits and manholes, igniting accumulated gases; from short-circuits in sockets, attachment plugs, receptacles, switches, and various other devices, all have been known to cause fire.

Overheating of wires, of motors, dynamos and switchboards from overloads; overheating of starting boxes; overheating of theater dimmers and regulating boxes from overload; overheating of improperly made joints, which may be considered as one of the weakest parts of an installation, and may include joints between wires, between wires and lugs, between lugs and bus-bars, or between switch blades and clips; overheating of magnet coils or resistances of arc lamps, and the innumerable other similar defects have been known to give rise to fires.

Other causes of fire may be the contact of an incandescent lamp with inflammable material, such as cotton, paper, wood, celluloid goods, etc., the melting of fuses, the breaking down of insulation, sparking from electrolysis, or short-circuits in places impregnated with inflammable gases, such as benzine, naphtha, ether, hydrogen, gasoline, and many others of explosive nature; also in any class of manufacture where vegetable material is distributed through the atmosphere in the form of dust, extra precautions are absolutely necessary, the least flash or arc is sufficient to cause an explosion and fire.

The disastrous fire which occurred in the Iroquois Theater, in Chicago, Ill., during the year 1904 was due to a piece of hot carbon falling from an exposed arc lamp. The hot carbon found lodgement upon a light gauze drop, which was quickly ignited and communicated fire to the rest of the scenery. This arc lamp was not a portion of the permanent equipment of the theater, but the property of a traveling show. It is strange to relate, but nevertheless true, that the various bodies appointed by municipal authorities everywhere to investigate the general fire condition and protection of various theaters, amusement halls, etc., lost sight entirely of the true cause of this fire, namely, defective electrical equipment which is shipped and carted about from one town to another during the theatrical season.

Careful inspection of the electrical equipment of traveling performers is a factor well recognized by the insurance interests. In some American cities since the Iroquois Theater fire, however, it has been deemed advisable to assist by authority of the law the insurance inspection departments in suppressing the use of any flimsy or otherwise defective equipment used by traveling theatrical companies.

Oily rags and waste have caused many fires of supposed mysterious origin. The spontaneous combustion of oily waste or rags is due to a rapid absorption of oxygen from the air, and the great avidity of many oils for oxygen. A strip of cotton or linen cloth saturated with boiled linseed oil and tightly wrapped, thrown among combustible material, will take fire in from three to four hours; also, if a cloth treated with linseed oil is subjected to any slight increase of temperature over 80 degrees F., spontaneous combustion is liable to occur.

With new-mown hay, hastily stacked, a fierce fermentation soon sets in. So long as water vapour alone is seen to escape, all may be well, but if a bluish vapour with a sulphurous smell is observed, the stack will certainly take fire. Hay, properly cured, is not much damaged, even if afterward partially

moistened, while being stacked, nor is it liable to take fire.

In all institutions employing watchmen, too much reliance is placed upon their services, unless watchmen's clocks are employed, with recording stations throughout the premises requiring the watchmen to register at regular intervals. Watchmen have more than once caused fire on the premises which they were supposed to protect, by dropping a lighted lantern, or falling asleep and allowing the lighted tobacco from a pipe bowl to fall among combustible material. In addition to watchmen's clocks in manufacturing buildings, warehouses, department stores, and institutions of a similar character, there should be an automatic auxiliary fire alarm system, connected with the city fire alarm system, by which an alarm could be immediately recorded at fire headquarters in the event of fire upon the premises. The criticisms regarding watchmen may seem harsh, but the writer has in mind a number of instances which justify them.

Care and cleanliness in all classes of risks are important and essential features. In closing for the day, all combustion should have especial substances liable to spontaneous care. All window shutters should be carefully closed; broken window-panes and broken sky-lights have been responsible for the spread of many fires. Stoves, furnaces and ash receptacles should have careful supervision.

If the building is electrically equipped, the opening of the service switch, thus disconnecting all current from the building, is advisable. This switch should be placed at a convenient point near the entrance to the building, and not in some dark cellar or vault, from which point the individual would have to light his path by means of burning matches, which would be very apt to bring about the condition he is seeking to avoid, namely, an accidental fire. Where watchmen are employed in an establishment, an approved system of electric lighting is preferable as a source of light to the types of lanterns usually carried by watchmen.

Better construction of all classes of buildings would do much toward reducing the fire hazard in general. The cheaper classes of buildings, such as dwellings and tenement houses, could be greatly improved by the omission of wooden lath in favour of expanded sheet metal. Retarding and fire-resisting building material represents money well invested.

In the compilation of this article, written by request of the editor of CASSIER'S MAGAZINE, the writer has not endeavoured to bring forth any new ideas, but to make a plain statement of facts of existing conditions from a fire-hazard standpoint as they present themselves to-day. The enormous waste of so much valuable property by fire is appalling, and the agonizing and frightful deaths suffered by the victims of fire should of itself alone be sufficient to cause every thinking man and woman to give their best efforts to better the present conditions.

THE CONDITIONS OF FAN-BLOWER DESIGN

By Walter B. Snow

A PRESSURE BLOWER

THE pressure which the atmosphere exerts at the surface of the earth is due to the weight of the air above it, and is to be measured by the weight of a column of air having the given area as a base and a height equal to that of the atmosphere. Obviously this height cannot be accurately determined. It is known, however, that the density of the air decreases in geometric ratio as the distance from the earth increases.

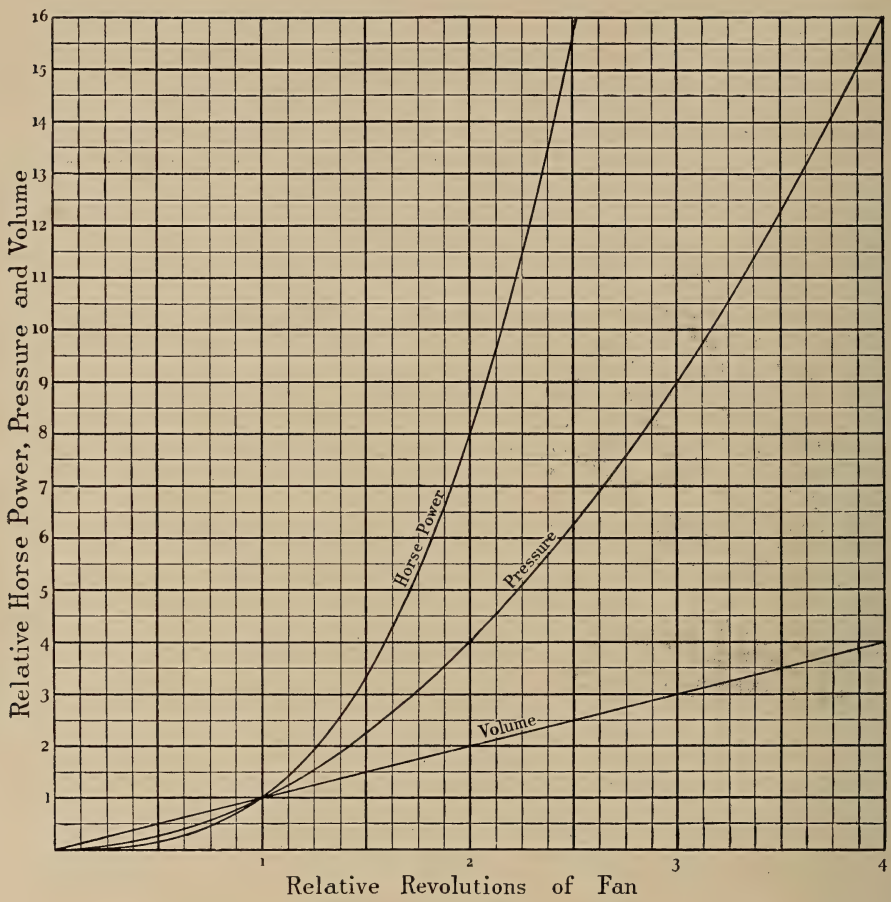
For the purposes of calculation, however, the practical equivalent of such a column may be determined by assuming the air to be of uniform density throughout, and the column to be of such a height and weight as to produce the observed effective pressure per unit of area. Under standard atmospheric conditions the theoretical height thus calculated would be a little over 27,000 feet. If from this height a solid body were dropped, the velocity upon reaching the earth would be determined by the well-known formula for falling bodies:—

$$v = \sqrt{2gh}.$$

This velocity is exactly equal to that realized if the pressure were entirely removed from a closed space under atmospheric pressure and the air allowed to flow into a vacuum,—namely, 1320 feet per second.

As the pressure is dependent upon both the height and the density of the fluid, it is evident that, for a given pressure, the less the density, the greater the height of the column. But the law of falling bodies recognizes the fact that it is the distance fallen through, and not the weight of the body, that determines its velocity. Therefore, in the case of a fluid, the less its density, the higher the column required to produce a given pressure, and the greater the velocity of discharge. From this it is evident that the velocity of a gas issuing under a given pressure is greater than that of a liquid under the same conditions; and conversely, the more dense the fluid issuing at a given velocity, the greater must be the pressure to produce that velocity.

In the case of a liquid, the atmospheric pressure upon the inlet and outlet of a containing vessel is balanced, and the actual height or head may be readily measured. But the air is invisible, and there is no tangible distinction in substance be-



THEORETICAL RELATIONS BETWEEN THE REVOLUTIONS OF A FAN, THE VOLUME DISCHARGED, THE PRESSURE CREATED, AND THE HORSE-POWER REQUIRED

tween that producing the pressure and that constituting the surrounding atmosphere.

As the total head represents the sole means of producing movement, whatever portion of this head is used for overcoming resistance reduces by just so much the amount that remains available for the production of velocity. That portion of the total head which is thus employed to overcome resistance is known as the pressure head, while that remaining and utilized for the production of velocity is designated as the velocity head.

In the case of air we have a fluid which is compressible, and hence varies in density with changes in the pressure and temperature. In ventilating and similar practice the variation due to change in pressure is too slight to require serious attention, but the conditions which obtain with mechanical draught demand careful correction for the density which varies inversely with the temperature. At a pressure of 1 pound per square inch, however,—the maximum ordinarily produced by a fan,—the density is increased about one-fifteenth over that of the atmosphere and must be taken into account.

As it is evident from the formula,

$$v = \sqrt{2gh},$$

that the velocity varies as the square

root of the head, density, or pressure, so also is it manifest that the pressure produced by a given velocity varies as the square of the velocity. Doubling the velocity, therefore, quadruples the pressure, while a threefold increase in velocity produces eight times the pressure.

The work expended in moving air is measured in foot-pounds by the product of the velocity into the total pressure, and manifestly varies as the cube of the velocity. Hence, doubling the velocity increases the power eightfold, while three times the velocity calls for the expenditure of twenty-seven times the work. The volume passing through a given opening would at first appear to be readily determined by multiplying the area of that opening by the velocity, but the form of the opening has much to do with the freedom of discharge. An orifice in a thin plate causes a material reduction in the area of the stream just beyond the opening, while a specially shaped outlet pipe reduces this contraction and tends to secure the maximum flow. The relative volume passing through different openings is indicated by the coefficient of efflux, which, for various shapes of orifices, is as follows:—

A DISC FAN

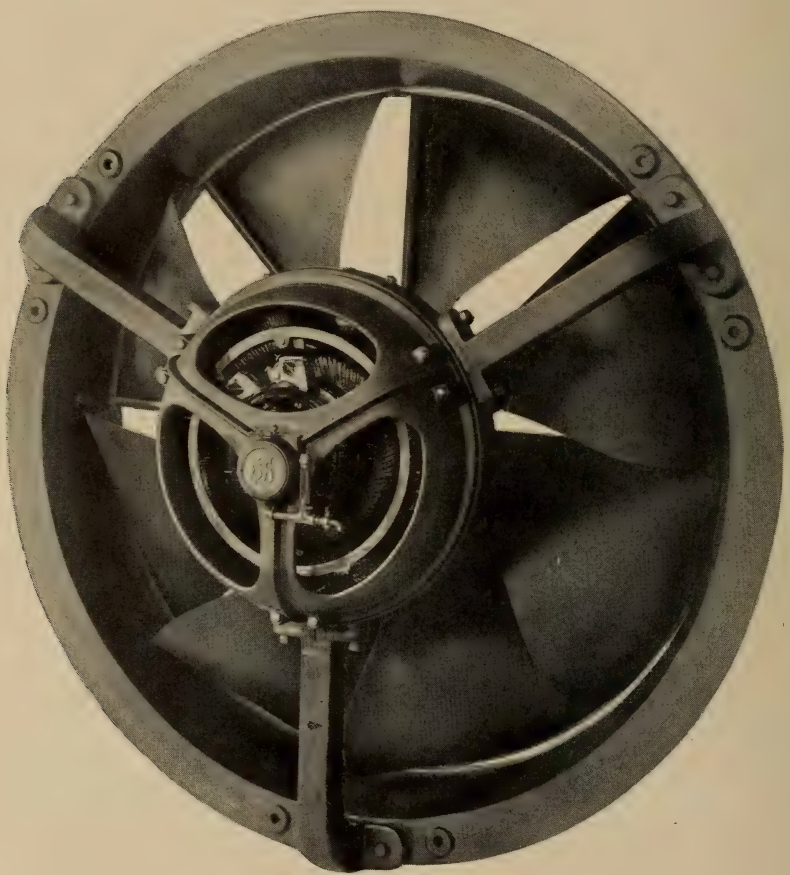
For an orifice in a thin plate	0.56
For a short cylindrical pipe	0.75
For a rounded-off conical mouthpiece	0.98
For a conical pipe whose angle of convergence is about 6 degrees	0.92

It is the province of a system for

the mechanical transport or movement of air to merely create a pressure difference between the ends of a conduit. The resulting rate of flow will be proportional to the square root of the difference.

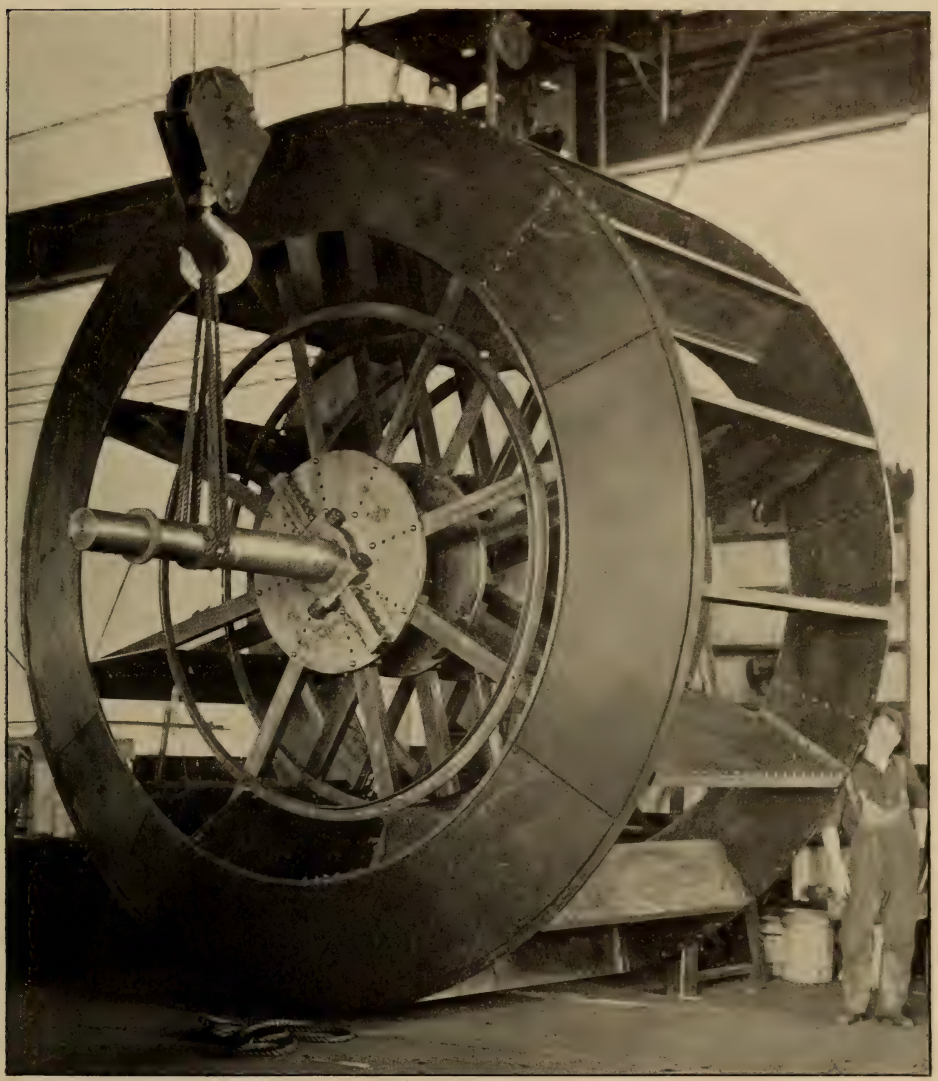
The simplest of all methods of creating such a difference is by heating the air within a vertical conduit, (of which the chimney is a familiar example), thereby inducing at the bottom an inflow of the cold and heavier outside air. But such a method is totally incapable of meeting many of the conditions presented in the practice of aerodynamics. Positive means are required. The air compressor, producing pressures of 100 pounds or over; the blowing engine operating within the usual range of 10 to 20 pounds per square inch; and the positive or rotary blower, seldom exceeding 5 pounds in pressure created, are not primarily designed for the mere movement of air, but more essentially for the creation of pressure and the transmission of the same through the medium of the air.

For mere movement of air at pressures under 1 pound per square inch,



AN ELECTRICALLY-DRIVEN PROPELLER FAN

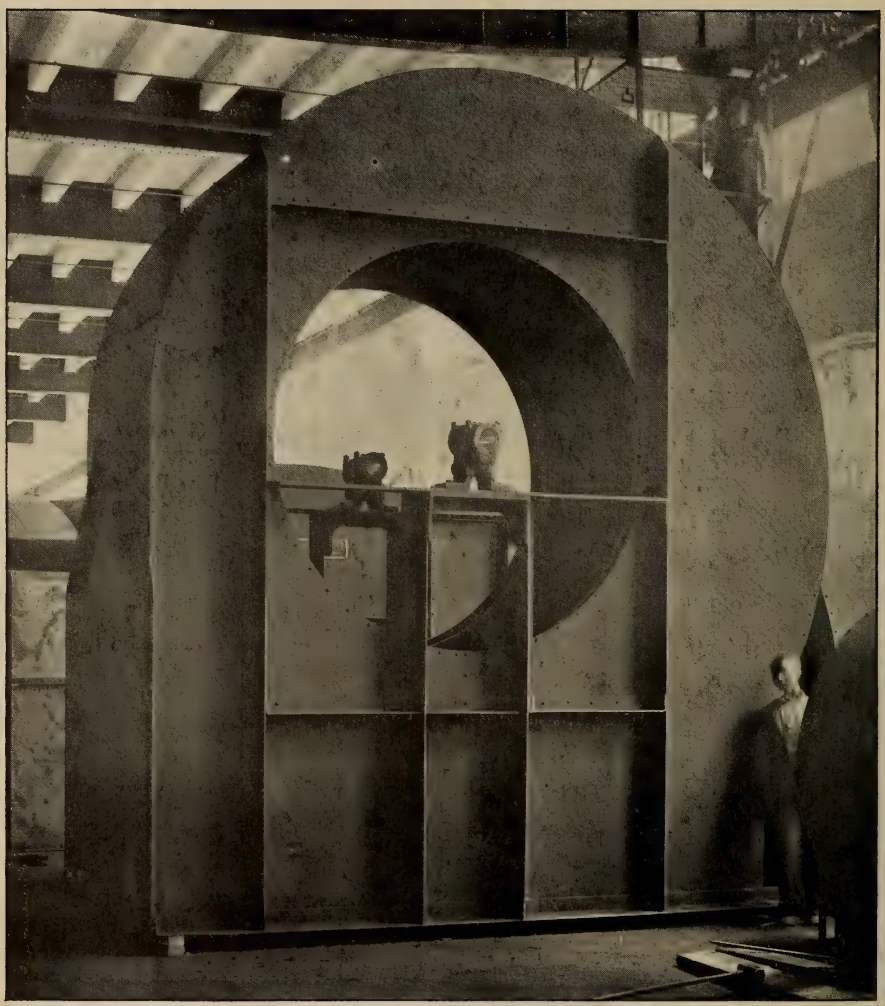
the disc or propeller fan and the centrifugal type of blower are the only mechanical devices of practical value. In the disc fan the blades are flat, set radially with their faces at an angle to the plane of revolution. By a wedging action each blade, as



A LARGE FAN WHEEL FOR VENTILATING PURPOSES

it revolves, removes in effect the support from behind successive volumes of air, and other air rushes in to supply the partial vacuum thus formed. The result is a continuous flow substantially in the direction of the axis of rotation. But centrifugal force also acts upon the air as it whirls around during the passage through the fan, throws some of it outward and causes the volume of discharge to take a conical form. Because of the angle at which the blades act upon the air, slippage or back-lash readily result when even moderate resistance is presented to the flow of air from such a fan.

In the design of the propeller type of fan, modeled on the lines of the screw propeller, more careful consideration is given to the forces acting upon the air, with the result that a more nearly cylindrical volume of discharge is secured and the



THE CASING FOR A LARGE VENTILATING FAN

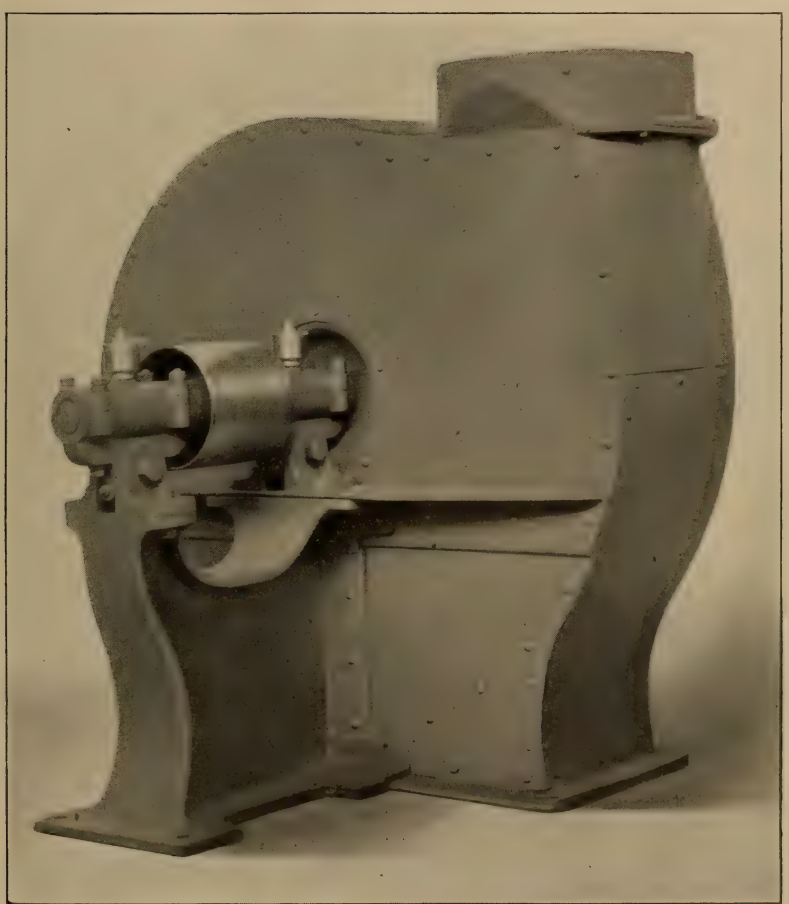
efficiency of movement is considerably improved.

For pressures above $\frac{1}{2}$ ounce, equal to $\frac{7}{8}$ inch of water, the centrifugal type of fan is, however, essential to the successful creation of pressure. Its action may be well illustrated by whirling a tube about an axis established at right-angles to its own and midway of its length. From the open ends the air is thrown out by centrifugal force while a partial vacuum is created at the axis of revolution. If an opening be provided at this axis, air will flow in and thus a constant current through the tube will be maintained.

In effect a centrifugal fan wheel is a series of such tubes radiating from an open centre, each being represented by the space which is enclosed between two adjacent blades and the side plates. Through each of these channels the air is thrown into the surrounding atmosphere or into the case which encloses the wheel, and, dependent upon the rate of flow thus established, air rushes in at the inlet in a constant effort to destroy the partial vacuum which is

there persistently maintained. Although an open running wheel may sometimes meet the requirements for exhausting purposes, yet it is customary to enclose the fan within a spiral case, which provides a constantly increasing area for the passage of air as it approaches the outlet from which it may be discharged through a pipe to the desired point of final delivery.

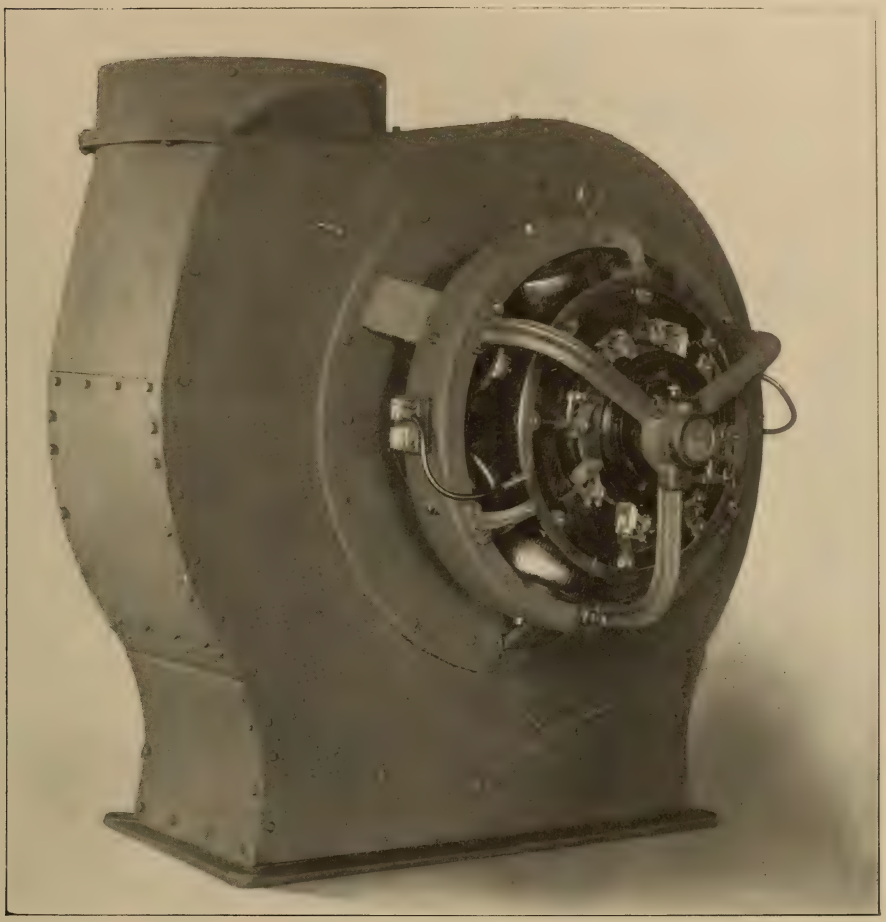
The maximum velocity at which air may be delivered through an outlet of proper area by a cased centrifugal fan with straight blades is substantially equal to that of the circumference of the wheel, while the pressure created corresponds thereto, being proportional to the square of the velocity. This area, commonly known as the capacity area, depends upon the proportions of the wheel, but in general ventilating practice is approximately equal to one-third of the diameter in inches multiplied by the width at the rim in inches. It is usually much less than that of the regular outlet in the casing. If the capacity area be reduced, the volume and power will be proportionately decreased while the pressure will remain substantially constant.



A STEEL PLATE EXHAUSTER

But both the volume and the power required will evidently increase with the area of the outlet, being greater

AN ENGINE-DRIVEN VOLUME FAN WITH THREE-QUARTER HOUSING

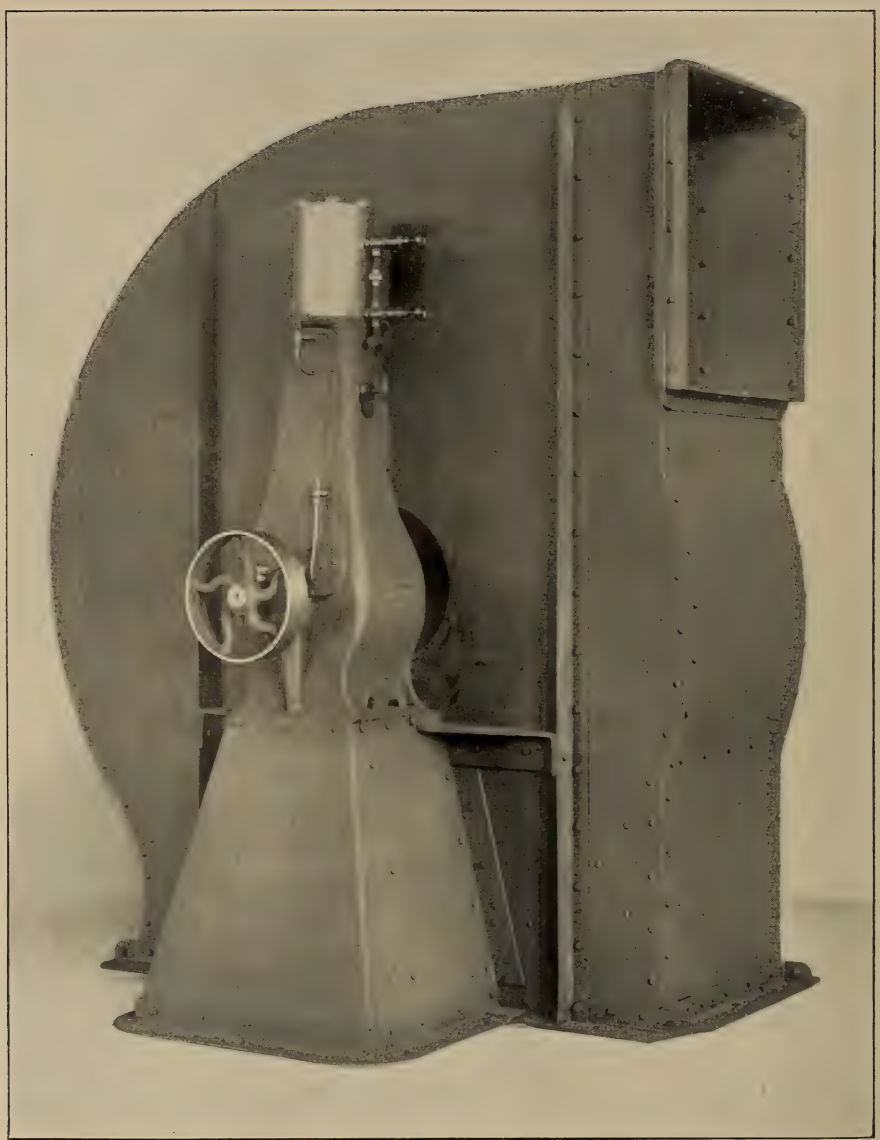


AN ELECTRICALLY-DRIVEN VOLUME FAN

with the normal outlet than with that representing the capacity area. But this increase will not be proportional to the area, for the pressure and consequently the velocity will be lower with the larger area. The greatest delivery of air and the largest consumption of power will occur when the casing is entirely removed and the fan left free to discharge entirely around its periphery.

For certain purposes, such as the blowing of cupola furnaces, a comparatively small volume of air is required, but under high pressure. In ventilating practice the volume is relatively greater, and the pressures less. When a fan is employed for exhausting hot air or gases, the speed required to maintain a given pressure difference is evidently greater than that necessary when cold air is handled, the difference being due, and inversely proportional to, the absolute temperature.

In the design of a wheel to meet given requirements, it is necessary to make its peripheral speed such as to create the desired pressure, and then so proportion its width as to provide for the required air volume. Evidently the velocity and corresponding pressure may be obtained either with a small wheel running at high speed, or a large wheel running at low speed. But if the diameter of the



AN ENGINE-DRIVEN VOLUME FAN

wheel be made too small, it may be impossible to adopt a width, within reasonable limits, which will permit of the passage of the necessary amount of air under the desired pressure. Under this condition it will be necessary to run the fan at higher speed in order to obtain the desired volume. But this results in raising the pressure above that desired, and in unnecessarily increasing the power required. On the other hand, if the wheel be made of excessive diameter, it will become almost impracticable on account of its narrowness.

Between these two extremes a diameter must be intelligently adopted that will give the best proportions. In practice the width of a ventilat-

ing fan seldom exceeds one-half its diameter. In a fan for high pressures the proportion may run as low as one to twenty.

Commercially, fans are classified as blowers and exhausters. The former type has an inlet in each side and cannot be readily applied for exhausting through connecting pipes.

The exhauster, which has an inlet in one side only, is, however, so designed as to permit of free connection thereto. The fan is overhung upon the shaft, while the pulley and both bearings of the motor are placed upon the closed side of the fan.

A further rough classification is usually made into volume and pressure fans. The former class particularly includes all fans designed for purposes of ventilation, mechanical draught and the like, in which quantity of air is the first desideratum. Although most ventilating fans run at speeds corresponding to pressures varying from half an ounce to an ounce, this is largely because lower speeds would call for fans of excessive size rather than because of the necessity of providing such pressures to overcome the resistances.

The pressure type of fan is more extensively employed for supplying, under pressures varying from 8 to 16 ounces, the air necessary for combustion in forges, puddling and foundry, cupola furnaces and the like.

The method adopted for propelling a fan depends upon the conditions under which it is to be operated. Small fans are almost universally belt-driven, but in large plants or isolated locations they are usually equipped with direct-connected engines or motors. To fulfil the exacting requirements of such service both engines and motors have been so adapted in design as to readily combine with the fans in forming exceedingly compact units. The great range between the motor output required for a fan delivering little air under high speed and pressure, and one discharging a large volume under slight resistance, and at low speed, is suggestive of the difficulties in the way of proper adaptation.

The ordinary commercial types and sizes of motors seldom fit the requirements for direct connection. Special designs are therefore necessary, such as are now being furnished by the leading fan manufacturers. In like manner the direct-connected engine has been developed for continuous operation under various conditions and with but little attention.

MODERN HOUSE WRECKING

By George E. Walsh

THE modern house wrecker on a large scale is a factor in industrial progress. His function is to demolish and distribute anything from a house to a bridge. His work has become essential to the evolution of modern building and engineering construction, for with improvements in all lines of structural work the necessity of tearing down old work to replace it by new and better work is as imperative as the science of designing and erecting. Wrecking companies, therefore, have been forced to organize their business on a purely scientific basis, and almost as much engineering skill is sometimes required by them to demolish structures to recover salvage as to build them.

According to the old method of tearing down buildings and structural designs, the work was conducted in a haphazard sort of way, and most of the materials eventually found their way into the junk house. The waste was enormous, and the returns to the owner or house wrecker were inconsiderable. With the organization of the big companies on a large scale, with shrewd engineers and contractors in their employ, skilled in estimating the value of second-hand material and its distribution, the work of demolishing has greatly eliminated waste. The distribution of this second-hand material affects the trade in a most important way, for the articles recovered from the wreck are sold everywhere.

Wrecking companies make contracts to demolish anything from a small building to a city. With enormous warehouses for the storage of the materials thus recovered, the selling and distribution of the goods may be carried on for years after. In addition to the storage houses, most of the wrecking companies have repair shops in which the second-hand materials are painted and fixed up so that in some cases they are nearly as good as new. Iron and steel structural material that has been in use for only a few years, machinery, house equipments, and the thousand and one small articles that are used for modern industrial purposes, can readily be repaired so that their life will be greatly extended.

The demolishing of such a city as the World's Fair at St. Louis is a monumental illustration of the work and value of the modern wrecking company. The salvage from such an enterprise is enormous, but it requires competent engineers and contractors to recover it. In many respects the skill demanded is equal to that required of the constructing engineer. It is a specialty which cannot be achieved within a day.

When the American Government took over the Panama Canal, the vast amount of abandoned machinery, houses, and engineering equipment had a certain value which it was difficult to estimate in advance. An American wrecking company offered to undertake the job of clearing the isthmus of all the old material left by the French engineers, the amount of salvage depending upon certain fixed conditions. Another company was reported to have made a direct offer of a million dollars for the houses and machinery. A good deal of the machinery was antiquated and almost useless for digging the Panama Canal, but, transported to other places, it could be made useful for small contractors in other lines

of work. The failure of the American Government to enter into a contract with any wrecking company may have been due to the peculiar conditions under which the French company's possessions were purchased, or to the fact that the government engineers believed they could save money by repairing such machinery and houses on the isthmus for future work. However, the offers of the wrecking companies indicate the stupendous scale of their operations.

To tear down and remove the buildings, machinery, and other paraphernalia from the World's Fair grounds at St. Louis will cost the company which secured the contract upward of a million dollars In enterprises of this nature, where the destruction of houses is foreseen from the beginning, the prospective wrecking companies have their agents on the scene from the time that the first installment of the building material goes up, and, as the work progresses, estimates of cost and value are made. A knowledge of the value of the material entering the structures greatly facilitates the final estimate.

The original cost of the building material, whether of lumber or structural steel, does not necessarily decide its price in the ultimate wrecking, for some second-hand articles have quite a marketable value independently of their first cost. Iron and steel structural parts are not materially injured when used a few years in buildings, and with a little repairing they can be made nearly as good as new, but the contractor, to accomplish this end, must know the grade and quality of the material when delivered. Usually, in demolishing a temporary structure or city, the engineers get access to the original specifications of the architect and builder, and they know exactly what they are figuring on in the final demolition.

The machinery and tool equipment of a great exhibition is frequently sold to a wrecking company along with the buildings. Such machinery is generally as good as new, for its use for exhibition purposes has occasioned very little wear and tear on it. At the St. Louis Exhibition a large quantity of new machinery was exhibited, and a good part of this was sold by the exhibitors to the wrecking companies. It frequently happens that such machinery exactly suits the needs of manufacturing companies in other places, and the wreckers make it their business to locate such possible customers.

The demolition of the St. Louis Fair buildings and equipments will hardly be completed when the wrecking companies will be ready to tear down and distribute the great mass of buildings and machinery of the Lewis & Clark Exhibition at Portland, Oregon. The latter is a smaller enterprise than the former. Estimates of the value of the exhibits already have been made by the large wrecking companies, and when the gates have closed on the last visitor the wreckers will be prepared to begin their work of destruction.

There is little of the haphazard destruction formerly so common among wreckers. It sometimes requires more skill to take down a large structure than to erect it, especially when every beam, girder, and board must be saved for future use. To an outsider it might appear at times as if the wreckers were simply destroyers, without trying to save as much as possible; but the contractors in charge are carefully watching the process, and only men accustomed to the wrecking business are employed to do the important work. Although something like 2000 men are employed in taking down the St. Louis Fair buildings and removing the machinery from the grounds, it will be found that every group or gang is under a foreman who understands his peculiar work.

The demolition of huge buildings occupying scores of acres of ground is both dangerous and difficult, and the wrecker must proceed with cau-

tion as well as with scientific forethought. The great mass of plaster and "staff" must be removed rapidly to lay bare the steel skeleton framework. The staff, composed of gypsum and other substances, is torn off in great strips and carted away for recooking and regeneration. It may not be as good as when first used, but it has a distinct commercial value and goes into other structures of less importance.

The steel skeletons of the buildings are the most valuable, and these must be taken down carefully and with precision. The average wrecker can dismember such a building so that the loss is restricted almost entirely to rivets and a few other small parts. Every beam, girder, and column is removed without injury, and after being numbered and repainted each one has an intrinsic value almost equal to the new.

Where does all this steel skeleton material go? Usually builders are eager to purchase it, often designing structures to fit the steel girders, columns, and beams instead of making the skeleton work fit the structures. The saving is so great that it pays builders and architects to study the situation. Anything that is left goes into storage for future use. The wrecking companies frequently dispose of fully half or three-quarters of their material to contractors on the ground, and they move it only to ship direct to purchasers.

Bricks, fireproof tiles, concrete blocks, and lumber are removed with the same care and for the same ultimate end. Modern masonry work can be taken apart by experts so that most of the bricks and stones are left intact. Instead of being broken up and sold as rubbish, the material is disposed of for new buildings. The metallic roofing and sheathing find ready markets, and after a little repainting they are nearly as good as new. The interior equipments of the buildings, from steam and gas pipes to marble basins, stone sills, and window frames go the way of all the other materials. A peculiar part of the business is the gradual invention of tools and appliances fitted especially for this line of work.

The work of taking down machinery, repairing it, and packing it for shipment to some purchaser is performed by expert mechanics, who, following the original drawings and blue-prints furnished them, seldom make mistakes. Thus at the St. Louis Exposition, many large dynamos and engines were dissected, and the parts numbered and shipped to distant points where they were put up again without damage to any part. Whole houses were taken apart and shipped on cars, for immediate reassembling, a thousand miles away. Belgian, Japanese, and Chinese buildings have been transported almost complete to the Pacific and Atlantic coasts by the wrecking companies.

The houses and machinery were bought for a mere fraction of the cost price; some which were put up at an expenditure of $50,000 to $150,000 were disposed of at prices ranging from $2000 to $6000. On the other hand, many small wrecking companies, less familiar with the best methods of taking buildings apart scientifically, lost money on their investments. The whole business is a science which demands close figuring, careful and systematic work, and close business methods in disposing of the materials.

The large wrecking companies have worked out the problem of utilizing even the smallest things. Even the materials that have to be demolished by dynamite have their use. A large plant for sawing and splitting waste lumber into kindling wood was temporarily constructed on the St. Louis Fair grounds, and for the next year or two kindling wood in that city will be cheaper than ever before. The same will be true of the Lewis & Clark Exposition when the buildings are finally pulled down.

The variety and amount of mate-

rials recovered and sold from a great exposition are almost inconceivable. The lumber alone recovered from the St. Louis Exposition will build houses enough to accommodate about 50,000 people Nearly half a million electric lamps were recovered from the wreck; also about 500,000 feet of lead-covered cables; 150,000 feet of wood conduits; nearly 100,000,000 feet of lumber; 16,000 carloads of staff; several million porcelain knobs, cleats, glass insulators, and sockets, used in electrical work; 1000 miles of iron piping, and about the same length of railroad track; office furniture enough to supply a town of 25,000 inhabitants; and millions of locks, hinges, window frames, sashes, bolts, electric fans, plows, jackscrews, trucks, and engineers' tools and machinery of every imaginable description.

The distribution of such a large miscellaneous collection requires a year or two of work, but eventually every part of the great exposition equipment will find its way into some use. Mementos of the great fair will spring up in the most unexpected parts of the country. The Philippine Reservation, for instance, is to be taken down and reconstructed in another part of the country as a novel summer resort, and its attractions will undoubtedly prove drawing features. The Kensington Orangery, built by the British Royal Commission, is to be moved bodily to Washington. The Falstaff Inn is to be used by an open-air theatrical company for presenting Shakespeare's plays. The Japanese buildings were sold to a company who will utilize them as a restaurant and summer amusement garden. The Jerusalem Concession Building will likewise figure prominently at a summer camp-meeting resort, and the building in which the battle of Santiago was performed will be perpetuated indefinitely in another part of the country for repetitions of this battle scene. The list of buildings and special novelty features that will be transported to new sites for future use could be multiplied indefinitely.

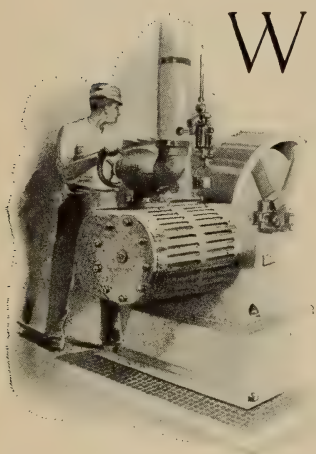
Similar disposition of the Lewis & Clark Exposition buildings and novelties will be made, and already their distribution has practically been arranged. Thus it will be seen that modern expositions are not so temporary in their results as is commonly believed. House wrecking companies have made it possible to perpetuate some of the special features so that parts of the exposition at least will go to the people, if the people will not come to them. Relics of the expositions will continue for years after the grounds have been restored to their normal conditions. It may indeed be a question whether in the future builders of expositions will not design many of their buildings and novelties with the ulterior view of having them transported to other parts of the country for temporary use.

POWER IN TALL OFFICE BUILDINGS

ITS COST AND DISTRIBUTION

By Charles H. Benjamin

The tall office building is essentially an American institution,—one of yearly growing importance in city districts where ground values are high. Professor Benjamin's article, therefore, as may have been inferred at once from the title, deals with American conditions, even local conditions, in so far as cost of labour and fuel are concerned, but his deductions are none the less generally interesting and valuable.—The Editor.



WITH the concentration of population and the consequent increase of land values in the large cities have come the tall office buildings,—steel structures, each containing from 50,000 to 250,000 square feet of rentable floor space and accommodating a daylight population of from 500 to 2500 people. Supplying the daily needs of these people in the way of air, light, water, heat, transportation and toilet privileges, makes a problem as complicated as that of caring for a medium-sized village.

The power plant of a modern office building is its very heart and lungs,—its most vital part, and from the start the building should be designed with especial reference to the most convenient arrangement and the most economical management of the engineering equipment.

The architect who arranges his columns and footings, his arches and girders, to suit his fancy, and then at the eleventh hour cannot find room for boilers and engines, is paying the penalty of his own short-sightedness and over-confidence.

In passing, it may be said that the failure to provide any adequate system of ventilation in most office buildings is a mistake which will sooner or later be regretted. No business man or his employee can do his best when working in the hot, stuffy atmosphere of the modern office.

It must be confessed that the engineer is not entirely sure of his ground when it comes to designing the power plant of an office building. Factory or station power plant practice has become crystallized in certain definite forms, but the modern sky-scraper and its requirements are still new, and the engineering field is comparatively unexplored.

The types of boilers, engines, and generators best adapted to the new environment, and the systems of heat, light, and air distribution that will best serve the owner and his tenants, involve questions still to be definitely decided. The present article is in no sense an attempt to solve any of the problems, but the writer hopes that it may throw some sidelights to illumine the path of the engineer.

In 1903, J. D. Wilson, of the American Elevator Company, of New York, reported in "The Engineering Record" some tests made on the power plants of several large buildings in New York City, and showed the expense of maintaining and operating the plants. Reference will be made in this article to some of the results quoted by him.

During the years 1904 and 1905, somewhat similar tests were made

under the writer's direction in three modern office buildings in the city of Cleveland, Ohio. The details of the tests were arranged and carried out by Messrs. Hicks, Selby, Daub, Sixt, Schoeplin, Nash, and Teachout, senior students in the Case School of Applied Science, at Cleveland. The tests were made at different times, but under approximately the same conditions. All of the buildings were new and of steel construction, and their equipments were modern. The several buildings will be referred to as A, B, and C.

Building A was a 14-story structure built of steel and brick with stone finish, and contained about 85,000 square feet of rentable floor space. It may be characterized as a high building, relatively narrow, and deep.

The boiler plant consisted of two Babcock & Wilcox water-tube boilers of the cross-drum type, each containing 2236 square feet of heating surface. These boilers could be fed either from the return mains or from the city service pipe as occasion might require. The furnaces were equipped with automatic stokers.

Two simple, automatic engines, built by the Skinner Engine Company, Erie, Pa., each connected to a 100-KW. direct-current generator, were used to furnish current for lighting and for running small motors.

A 15-H. P. motor was used for driving the ventilating fan. Hydraulic elevators driven by Worthington duplex pumps were used in this building, a compound, single-acting pump being used during the day and a simple, double-acting one for night service. Two feed-pumps for the boilers, two small service pumps for the upper part of the building, two small air pumps, and an ice machine for cooling drinking water, completed the outfit.

A boiler test of 24 hours' duration was made on but one of the boilers, as the boilers were precisely alike and either one was capable of running the plant under average conditions. The atmospheric temperature on the day of the test was 42 degrees F., which may be considered an average value for the spring months in that latitude.

The test was made according to the usual rules for such work, with results as shown in Table I. The total amount of coal consumed during the 24 hours was 17,465 pounds, accompanied by an actual evaporation of 131,839 pounds of water, or approximately $7\frac{1}{2}$ pounds of water per pound of coal. The average boiler horse-power developed was 170, and the equivalent evaporation per pound of dry coal was 8.33 pounds of water,—a good rate for soft coal slack.

The two engines were tested to determine the average indicated and electrical horse-powers. The average indicated horse-power of engine No. 1 between the hours of 4 and 7:45 p. m., the time of heaviest load, was 92.25, and the electrical horse-power taken at the switchboard was only 69.64, showing a combined efficiency of only 75.5 per cent.

Engine No. 2 tested between the hours of 3:30 and 7.00 p. m. showed indicated and electrical horse-powers of 87 and 66.57, respectively, or a combined efficiency of 77 per cent.

The elevator system was tested by estimating the horse-power of the pumps and by counting the number of trips made by the elevators, together with the number of passengers carried in a given time. The test lasted for 6 hours, and during this time 2598 passengers were carried from the ground floor by the elevators, and 372 between floors, making a total of 2970. The average horse-power generated by the pump in this time was 23.35. No test was made of the smaller pumps used about the plant.

Readings of the wattmeter during the 24-hour test on the boilers showed an average horse-power consumption by the generator engines of 48.29. As the average efficiency of the en-

gines was 76 per cent., this would correspond to 63.5 indicated horse-power. For convenience of comparison, the horse-powers of both engines and elevator pumps were reduced to equivalent boiler horse-power by assuming the engines to use 36 pounds of steam per horse-power per hour, and the elevator pumps 50 pounds.

On this basis, about 33 boiler horse-power were required to run the elevator pump, and 66 boiler horse-power to run the engines, or a total of, we will say, 100 H. P. of boiler to take care of electric and hydraulic service. The remaining 70 H. P. must be charged to feed and service pumps, and to the refrigerating and air compressor service, as the building was heated by exhaust steam. Live steam was used to supplement the exhaust in extremely cold weather, but none was used on the day of test.

Building B was a fourteen-story structure of steel and brick, having much the same general proportions as building A, and containing about 100,000 square feet of rentable floor space. The several tests were conducted in much the same manner as those just described.

There were three boilers of the horizontal fire-tube type built by the Erie City Iron Works, and equipped with Murphy automatic stokers. Two tests were made, one of 18 hours and one of 17 hours' duration, using each time two of the boilers. The average horse-power developed in the first test was 153, and in the second test 148, the combined heating surface of the two boilers being 2530 square feet in each case. The average equivalent evaporation per pound of dry coal was 7.5 pounds of water. See Table I.

There were two engines built by the Harrisburg Foundry & Machine Works, of Harrisburg, Pa., direct connected to two-phase alternators built by the Westinghouse Electric & Manufacturing Company, of Pittsburg, Pa. The exciters supplied direct current to different parts of the building.

Indicator tests on the engines showed an average combined efficiency of 80 per cent. for engine No. 1, and 84 per cent. for engine No. 2. The average indicated horse-power from 6 a. m. to 4 p. m. was 56, from 4 p. m. to 7:30 p. m. was 68, and from 7:30 p. m. to 11 p. m. was 33. The average horse-power for the entire day of 17 hours was 54. Assuming 36 pounds of steam per horse-power per hour, the boiler horse-power would be 57.

Hydraulic elevators were used, driven by two double-acting duplex pumps. One of the pumps was run continuously, and the other intermittently, and the number of strokes of each was counted for an entire day's run. The total average horse-power for both pumps was 21.5. Assuming a steam consumption of 57.5 pounds per horse-power per hour, makes this equivalent to 36 boiler horse-power. The number of passengers carried by the elevators during the day's run was 2592 in 1014 trips, including passengers taken on between floors.

In building B there was accordingly an average during the day of 151 boiler horse-power, of which 57 was used by the generator engines and 36 by the elevator pumps, leaving 58 H. P. to be used by feed pumps, service pumps, air pumps, ice machine and freight elevators.

Building C was tested last, and the details were worked out rather more carefully than in the cases just described. This was a building of the same general type of construction as A and B, but of very different proportions. It was only ten stories in height, but covered a large area and contained 240,000 square feet of rentable floor space.

The three boilers used were of the horizontal tubular type, rated at 150-H. P. each, and equipped with mechanical stokers. The boilers were built by the Brownell Company, of Dayton, Ohio. Two of the

boilers were tested between the hours of 5 a. m. and 11 p. m. The average horse-power developed by the two boilers was 176; with 1921 square feet of heating surface, an evaporation of 7.06 pounds of water per pound of dry coal was maintained. Considering the fact that the boilers were run only at about one-half their capacity, this is a good performance.

The three generator engines were of the simple, high-speed automatic type made by the Ball Engine Company, of Erie, Pa. These were connected to 100-KW. direct-current generators made by the Western Electric Company, of Chicago, Ill., the current being used both for lighting and for elevator service.

An all-day test of the engines for 17½ hours showed an average indicated horse-power of 104, the load varying from about 25 H. P. in the early morning to 160 H. P. during the rush hours from 6 to 8 p. m. During the day the average electrical horse-power shown at the switchboard was 82, giving a combined efficiency of about 78.7 per cent.

The remaining power equipment consisted of a compressor pump supplying compressed air for the use of tenants, two service pumps for water supply above the sixth floor, a 7-H. P. ammonia ice machine used only during the summer months, and a 10-H. P. Root blower for a pneumatic cash delivery system. There were four electric elevators built by the Otis Elevator Company, of New York, for public use, and three private elevators of the same type. Exhaust steam was used for heating the building by a vacuum system, but live steam can be used when necessary.

The steam consumption of the various engines and pumps used in this plant was determined by calculation as far as possible. For instance, in the case of the generator engines, an average set of cards was selected, and the volume of steam shown by the indicator was determined for points on the expansion line near release. An allowance was made of 15 per cent. for condensation at this point, and the weight of steam used calculated accordingly. This gave a steam consumption of 33 pounds per horse-power per hour, or nearly the same as the boiler horse-power. A similar test and calculation gave 10.6 boiler horse-power for the blower engine.

The horse-power of the feed pump was calculated from the speed and pressure, and assuming 200 pounds per horse-power per hour for the steam consumption gave 18 boiler horse-power. In a similar manner 15.8 boiler horse-power were determined for the vacuum pump, and 4.8-H. P. for the service pump. A summary of the use of steam in this plant would then be as follows:—

Under the conditions as to feed and temperature of evaporation, 33 pounds of steam per hour represented one boiler horse-power, and the boiler developed 176 of these units. This steam was used in the following manner:—

	Horse-Power
Generator engines	104.6
Blower engines	10.6
Feed pump	18.2
Vacuum pump	15.8
Service pump	4.8
Compressor pump	4.1
	158.1

This leaves 18 H. P. unaccounted for, but which can be charged to the stoker engine and to heating and radiation. The allowance of 200 pounds of steam per horse-power per hour for the pumps may seem excessive, but tests made on similar pumps by the writer have shown results as high. The amount of power used by the electric elevators was ascertained by placing a wattmeter in an elevator circuit for two weeks.

Three of the four public elevators ran regularly, while one was used only occasionally. An analysis of the total electric power generated showed that 16.4 per cent. were used by the elevators, 29 per cent. were metered and sold to tenants, and the remainder or 54.6 per cent. were consumed in lighting the building.

This gives an average of only 17-

H. P. for elevator service,—much less than in either of the other buildings. The total number of trips made per day by all four elevators was 910. The number of passengers carried was not determined.

TABLE I.—SUMMARY OF BOILER TESTS

Building	A	B-1	B-2	C
Duration of test (hours)	24	18	17	15
Steam gauge (pounds).	115	102	104	108
Temperature of air....	42	36	38	43
Temperature of flue....	402	393	309	284
Temperature of feed...	183	156	182	207
Dry coal consumed....	16,941	13,875	10,600	12,910
Total refuse	2,278	1,413	1,400	2,280
Dry steam generated...	131,840	86,670	81,340	87,070
Equivalent evaporation per lb. of dry coal...	8.33	6.86	8.23	7.06
Per lb. of combustible.	9.62	7.45	9.48	8.56
Average horse-power...	170	153	149	176
Heating surface	2,236	2,530	2,530	3,840
Number boilers tested.	1	2	2	2
Type of boiler.....	W. T.	R. T.	R. T.	R. T.

TABLE II.—DISTRIBUTION OF POWER

	A	B	C
Average horse-power generated by boilers	170	151	176
Used by generator engines....	67	57	105
Used by elevator pumps.....	33	36	Electric
Used by blower engines.....	..	..	10
Used by vacuum pumps.....	..	..	16
Used by feed pumps.....	..	..	18
Used by service pumps.....	..	..	5
Used by compressor pumps...	..	..	4
Used in heating, etc.....	70	58	18

The boiler horse-power used in the table means 34½ pounds of steam at 212 degrees, per hour. It is to be remembered that the 105 engine power in building C includes 17-H. P. for electric elevators and 30-H. P. metered and sold to tenants.

TABLE III.—COST OF BOILER HORSE-POWER FOR ONE MONTH

	A	B	C
Total coal in tons..... ...	255	150	258
Cost of coal.....	$471.60	$285.00	$465.00
Chief engineer	100.00	100.00	150.00
Assistant engineers (two)	140.00	65.00	140.00
Oiler	50.00	40.00	45.00
Firemen (two)	100.00	110.00	120.00
Supplies and repairs.....	50.00	60.00	56.00
Total cost	$911.60	$660.00	$976.00
Horse-power generated ..	170	151	176
Cost per horse-power per month	$5.34	$4.37	$5.55
Cost per horse-power per day	0.178	0.145	0.185

The high cost of power compared with that in a power plant is due to the boilers being run so much below their capacity. For instance, in building C, the boilers were easily capable of doing twice what was required of them. Assuming, however, that 300-H. P. were developed without any change in the rate of evaporation or in the working force, the total expense for one month would be $1305 or $4.35 per horse-power per month.

No allowance has been made in Table III. for rent, interest, or depreciation.

TABLE IV.—COST OF ELEVATOR SERVICE PER MONTH

	A	B	C
Boiler H. P. used....	33.35	36.	17.15
Cost of power.....	$178.40	$157.32	$95.25
One starter	50.00	50.00	60.00
Operators	170.00	155.00	195.00
Maintenance	5.00	5.00	5.17
Total cost	$403.40	$367.32	$355.42
Cost per day.....	13.45	12.24	11.85
Cost per passenger....	0.0023	0.0047	.....
Cost per trip.....	0.0095	0.012	0.013

A month of 30 days has been used in all the calculations to give comparisons with power plant expense.

TABLE V.—TOTAL COST OF POWER FOR BUILDING

	A	B	C
Cost per month (30 days)	$911.60	$660.00	$976.00
Cost per day.....	30.39	22.00	32.53
Cost per year (365 days)	11,100.00	8,030.00	11,850.00
Cost per year (308 days)	9,360.00	6,776.00	10,000.00
Rentable floor space in square feet....	85,000	*100,000	239,950
Cost of power per square foot space per year	$0.131	$0.08	$0.0495
Cost of elevator service per year (365 days)	2,740.00	2,555.00	3,160.00
Cost of power, including elevator service	13,840.00	10,585.00	15.010.00
Total cost per square foot of space per year...	0.163	0.106	0.0626

* Estimated.

These figures seem very low when compared with those given by Mr. Wilson, previously mentioned. Below is given a summary of three tests reported by him:—

Number of stories.....	15	18	16
Rentable floor space in square feet	56,900	104,000	112,000
Cost of power per year per square foot.....	$0.35	$0.15	$0.40

These figures are for costs outside of elevator attendance. Both the fuel and the water in New York cost about double what they do in Cleveland; this will in part account for the difference.

The extremely low cost shown by

building C would seem to indicate better economy in power for a moderately high building covering a large area than for the tower-type of building. The use of electric elevators in place of hydraulic elevators points to a saving in power. The cost of electric power in this building was about 2 cents per kilowatt-hour.

The writer wishes that in some respects these tests had been more complete, but as much was done as the circumstances and the pressure of business would allow. As the data stand, it is hoped that they throw some light on the question of the cost and the distribution of power in the tall office building.

CONTRACTORS' LOCOMOTIVES

By J. F. Gairns

IN the issues of this magazine for July, August and September, 1904, the writer dealt with the subject of "Industrial Locomotives" operated by steam, petrol or gasoline, compressed air, and electricity; but in the steam section prominence was given to engines adapted for special industrial requirements, and the mines, quarries, and manufacturing establishments, is a very important one, for these engines exist in thousands all over the world, and their manufacture constitutes a large portion of the work of most locomotive firms, while there are many other firms which are devoted almost exclusively to such work; and in the

FIG. 1.—A FOUR-WHEEL LOCOMOTIVE BUILT BY MESSRS. PECKETT & SONS, BRISTOL, ENGLAND

ordinary classes of what are known as contractors' locomotives were only briefly referred to in introduction.

The subject of contractors' locomotives, however, by which generic term is meant any locomotive engine adapted for the use of contractors, and in and around coal and other present article the main conditions governing the design and construction of such engines and their field of usefulness are briefly reviewed, a representative selection of photographs being reproduced by way of illustration.

It must, however, be understood

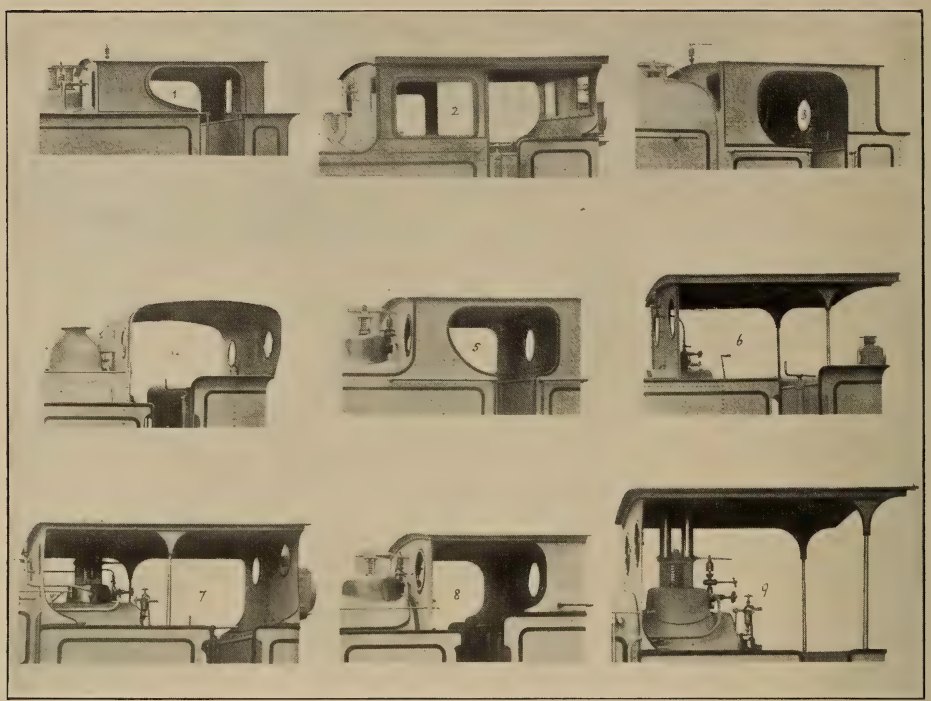


FIG. 2.—DIVERSITY OF CAB FITTINGS TURNED OUT BY MESSRS. HUDSWELL, CLARKE & CO., LTD., LEEDS, ENGLAND

that this article does not purport to describe locomotives of each type considered as built by a particular firm, nor to deal with the work of every firm which builds contractors' locomotives, and it may be that some firms may build engines which are better illustrative of a particular argument than those selected for illustration by the writer; but the selection of photographs for reproduction has been made from a large collection in the writer's possession, with due regard to the course of the article and the necessarily limited space at disposal.

Contractors' locomotives, whether large or small, or for use on standard or broad or narrow-gauge tracks, are generally required to work under very variable circumstances, and the character of the work is best described as more or less odd-and-end.

In some cases they are employed hauling materials from one place to another in connection with large building, dock, railway, and like contracts, and in removing "spoil" (generally in small trucks or "tubs") from excavating and like machinery; and, as a rule, they have to travel with fair loads at reasonable speeds over roughly laid tracks with sharp curves and badly fitted points and crossings.

In other cases they are employed serving cranes or tips for transferring coal, stone, bricks, earth, and general goods to vessels, lighters, and barges, or in removing trucks loaded therefrom.

In docks, and about coal and other mines, quarries, etc., they are used in large numbers for shunting purposes, and for hauling coal, ore, stone, slate, and other like materials from the pit head or quarry to a waterside wharf or a railway siding. In such cases the dock, mine, or quarry company usually owns a considerable stock of locomotives, for there is generally a large amount of work to be done, and the private tracks often extend for several miles to the river side or to a seaport, or to an exchange sid-

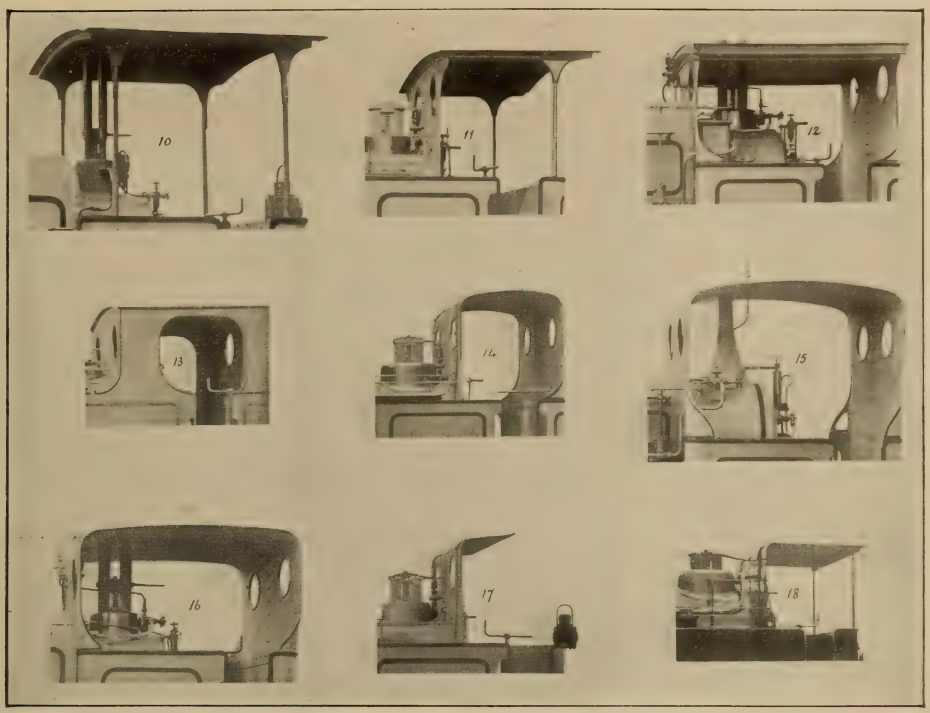


FIG. 3.—SOME MORE CAB FITTINGS FROM THE WORKS OF THE SAME BUILDERS

ing with a main railway. Such lines are very common in most mining districts, and there are many instances where the mining company runs its own trains over its own lines for many miles, even though the collieries concerned may be located close to a main line of railway.

In eastern, colonial and tropical, or semi-tropical countries, contractors' locomotives (generally small) are very largely employed for plantation work or about large agricultural or similar estates.

About extensive industrial establishments, such as shipbuilding yards, steel works, iron foundries, blast furnaces, gas works, etc., contractors' locomotives are also largely used for conveying coal, coke, ashes, pig iron, ladles of molten metal, castings, machine parts, manufactured articles, stores, etc., between the various buildings and departments, and between the works and a waterside wharf or a main railway siding.

The larger classes of contractors' locomotives correspond in many respects with the practice of the large railways, and it sometimes occurs that for shunting and miscellaneous work the main railway companies purchase engines from builders of contractors' locomotives in preference to building the required engines at their own works or to their own designs. In some instances private firms have running powers whereby their own engines work for some distance over the tracks of a main railway, the engines then operating under regular traffic rules, and being obliged to satisfy certain requirements.

The main conditions which govern the design of contractors' locomotives may be briefly described as follows, though not all of them apply in every case, as will be seen when specific examples are described later:—

I.—SIMPLICITY OF CONSTRUCTION

It is not generally advisable to introduce many of the special features

FIG. 4.—A SADDLE-TANK LOCOMOTIVE BUILT BY MESSRS. ANDREW BARCLAY, SONS & CO., LTD., KILMARNOCK, SCOTLAND

of design which are found in the design of main railway locomotives. A plain straightforward type of boiler and fire-box, that is not liable to get out of order readily, that can be easily and frequently cleaned (particularly if bad water is used) with a minimum of trouble and expenditure of time, and that can be repaired conveniently; cylinders, wheels, motion, and valve gear that can be easily got at for repairs, or removed, replaced, and readjusted without requiring special skill or repair shop facilities and appliances; parts and fittings of simple construction and adapted for the easy and rapid substitution of a duplicate so that the engine can be quickly got to work again after a breakdown or failure; these are the main considerations which have to be taken into account in designing these engines.

II.—SMALL SIZE, LIGHTNESS ON TRACK, FLEXIBILITY, GREAT PROPORTIONATE POWER AND (OFTEN) RAPID ACCELERATIVE ABILITY

The first three of these items explain themselves when it is remembered that contractors' engines more often than not work over very roughly laid temporary tracks, with sharp curves and with badly fitted and designed points, and crossings. The engines are also required, as a rule, to be able to haul good loads and to get away quickly at a start, notwithstanding the various disabilities arising from other causes. Larger engines, however, work in many cases under more favourable circumstances, for the fact that powerful engines are employed entails the provision of proper and sufficiently strong, and well-laid tracks for them to run upon.

For small engines, four wheels only are employed, as a rule, all coupled, and it is not very usual to have any additional wheels except in Continental countries, and occasionally in British and American practice when carrying wheels, arranged in a two-wheeled or four-wheeled bogie frame, are sometimes fitted to provide an extended wheel base while at the same time allowing for the required flexibility. With four wheels only, most of the requirements can ordinarily be complied with, and although this often entails that an engine has considerable overhang at one or both ends, and is therefore somewhat "rocky" while travelling, this does not matter much, as the speeds are not high. For more powerful engines and for small engines,

when it is desired to keep weights per axle low, six-coupled wheels are the rule, generally placed close together to restrict the wheel base. Occasionally eight-coupled wheels are employed, but in such cases the engines are very large and powerful machines. Outside cylinders are most frequently employed for four-wheeled engines, and very largely also for six-coupled and large engines.

III.—STYLE AND ARRANGEMENT OF WATER TANKS, AND THE PROVISION OF SPECIAL APPLIANCES AND FITTINGS

In British and American practice, the employment of saddle water tanks is most common, but, rather

FIG. 5.—A FOUR-WHEEL LOCOMOTIVE BUILT BY MESSRS. HAWTHORN, LESLIE & CO., LTD., NEWCASTLE-ON-TYNE

FIG. 6.—A FOUR-WHEEL, SADDLE-TANK LOCOMOTIVE BUILT BY THE HUNSLET ENGINE COMPANY LTD., LEEDS

FIG. 7.—A 36-INCH GAUGE FOUR-WHEEL LOCOMOTIVE BUILT BY MESSRS. HUDSWELL, CLARKE & CO., LTD., LEEDS

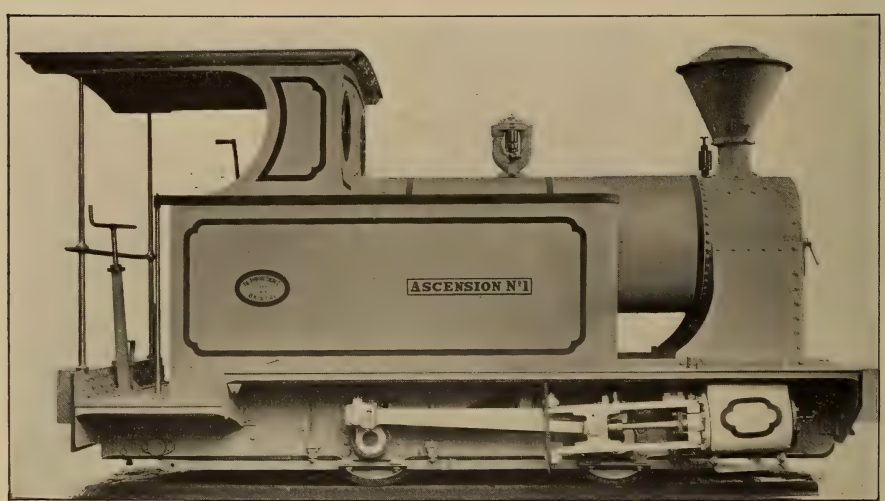


FIG. 8.—A LOCOMOTIVE ADAPTED FOR WOOD BURNING. BUILT BY THE AVONSIDE ENGINE COMPANY BRISTOL

curiously, there appears to be a decided predilection for side tanks in Continental practice, saddle tanks being there exceptional. For small engines the water storage provided for sometimes consists merely of two or three small tanks placed between the frames or about the engine. When an engine is not required to travel far from its base of operations, no bunker or fuel storage space is necessary in many instances, the rear of the foot plate having merely a protecting hand rail or back plate. It is very rarely that tenders are provided for contractors' locomotives. Special appliances and fittings are generally few in number, and as far as possible

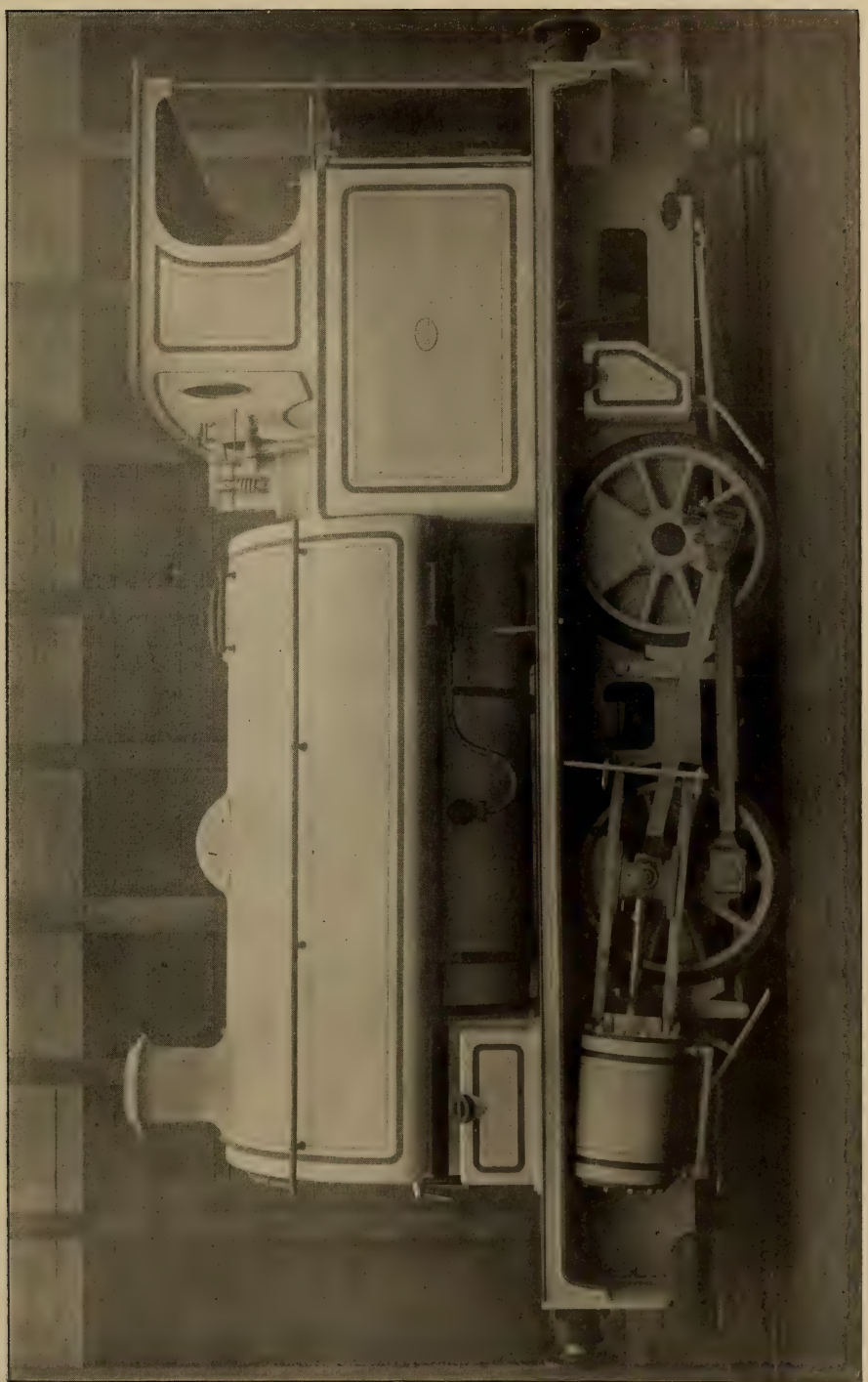


FIG. 9.—A FOUR-WHEEL, SADDLE-TANK LOCOMOTIVE BUILT BY MESSRS. W. G. BAGNALL, LTD., STAFFORD, ENGLAND

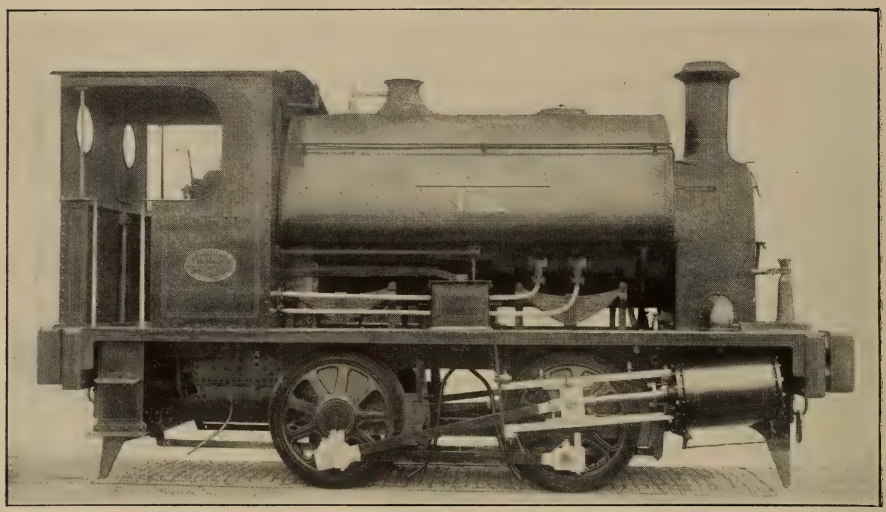


FIG 10.—A FOUR-WHEEL, SADDLE-TANK LOCOMOTIVE BUILT BY THE BRUSH ELECTRICAL COMPANY, LTD., LOUGHBOROUGH

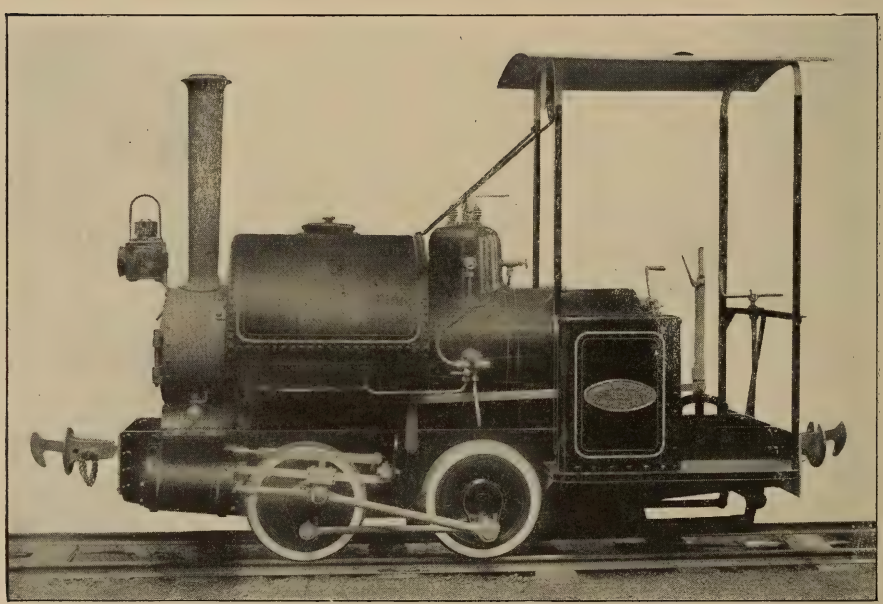


FIG. 11.—A SMALL FOUR-WHEEL LOCOMOTIVE BUILT BY MESSRS. KERR, STUART & CO., LTD., LONDON

only those are provided which are indispensable. This is particularly the case with engines which must be operated by one man. Occasionally contractors' locomotives are fitted with Westinghouse or vacuum brakes, and steam brakes are somewhat common; but, as a rule, hand brakes only are provided. Now and then contractors' locomotives are fitted with condensing apparatus for use in confined spaces or in tunnel construction; but this is exceptional.

It will be gathered from the foregoing that the design of contractors' locomotives rests almost entirely with

the builders, in contrast with the design of main railway locomotives, which is generally done by the railway officials who supply the specification and drawings to a firm of locomotive builders, and it is therefore usual for purchasers of contractors' locomotives to state their requirements, the builders taking the responsibility of providing an engine meeting such requirements, either by supplying a stock engine or modifying a standard design, or, when necessary, preparing a special design. It, therefore, follows that there is generally a strong family likeness between engines built by a particular firm. This is, however, modified considerably in practice by the fact that, although the main features of a design may be maintained through many engines, they may differ very much as regards appearance because of the fitting of various styles of chimneys, cabs, safety valves, and details according to customers' requirements or wishes.

The general particulars which govern the type or design of engine supplied by a firm to meet the purchasers' requirements is well set out by the following extract from a blank instruction sheet issued by a well-known British firm of builders of contractors' locomotives,—the Hunslet Engine Company, Ltd., of Leeds:—

This company, having made a specialty of the construction of locomotive tank engines, is prepared to supply engines adapted for any gauge of railway or work, and to determine what is the most economical and suitable for the duty to be performed, requires the following information:—

1. Gauge of railway.
2. Weight of rails per yard, distance apart of sleepers, and whether joints are fished or not.
3. Length of journey which the engine is required to make without a stop.
4. Distance between watering stations.
5. Description of fuel to be used.
6. Length of radius of sharpest curve.
7. Length and gradient of steepest incline, and whether engine has to start on the incline or not. If any curve on the incline, the radius of the sharpest to be given.
8. Greatest gross load in tons, including wagons or carriages, which the engine is required to take at one time.
9. Height from top of rail to center of buffers. If side buffers are used, transverse centers also to be given.
10. If limited to height and width, extreme dimensions to be given.

As indicative of the diversity of cab fittings, the series of illustrations reproduced in Figs. 2 and 3, and extracted from the catalogue of Messrs. Hudswell, Clarke & Co., Ltd., of Leeds, will be of interest. It will, of course, be understood that all firms modify their designs in similar fashion to suit customers.

Some firms which build contractors' locomotives are prepared to hire out engines when customers require them only temporarily, and in many cases they will guarantee to keep engines in repair for a stated sum. It is very usual for a set of duplicate parts to be provided with a new engine, particularly if the engine is going abroad; and most firms have a complete cable code by which new parts can be ordered by cable without giving details. A considerable business is also done with second-hand contractors' locomotives, both by building firms and by dealers in engineers' machinery and apparatus.

A feature of the business of supplying contractors' locomotives is that firms guarantee quick delivery. If a stock engine will meet requirements, delivery can be made at very short notice, but under other circumstances, as many stock parts can be utilized when the firm provides its own designs, engines can be delivered on the purchasers' premises, or on shipboard, within two or three weeks. A few months ago a British firm achieved a record in this way, for a six-coupled tank engine, which was not of stock design, and which required many of the usually stocked parts to be made specially, was delivered on board a vessel at a port about a hundred miles from the town of manufacture within ten days from the receipt of instructions.

Contractors' locomotives are usually owned in fair numbers,—from ten to thirty or more,—by large contracting firms, dock companies, and mining firms; but there are many thousands of firms which possess engines in less numbers, so that the extent of this branch of the locomotive building industry will be realized somewhat.

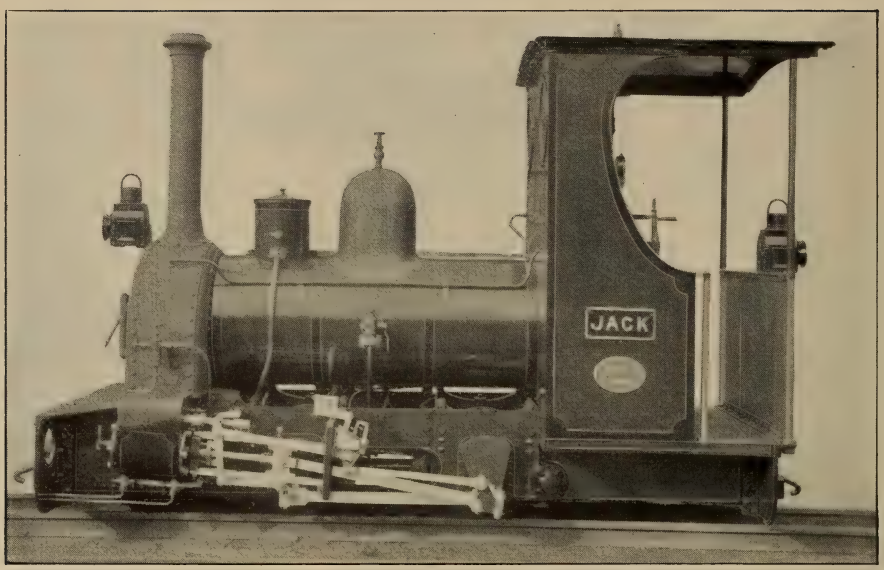


FIG. 12.—A FOUR-WHEEL LOCOMOTIVE FOR 18-INCH GAUGE. BUILT BY THE HUNSLET ENGINE COMPANY, LTD., LEEDS

It may be mentioned that at Woolwich Arsenal there is a very extensive railway system, some on the 18-inch gauge and some on the standard gauge, and about fifty engines are employed of all types, styles, and sizes (from the writer's recollection of some years ago, there are hardly two engines alike), most of the building firms being represented.

SOME SPECIMEN LOCOMOTIVES

It will now be in order to describe a selection of contractors' locomotives as reproduced in the accompanying illustrations. Fig. 1 illustrates a very large and powerful four-wheeled engine, the builders being in this case Messrs. Peckett & Sons, of Bristol. All the work of this firm is characterized by a particularly no-

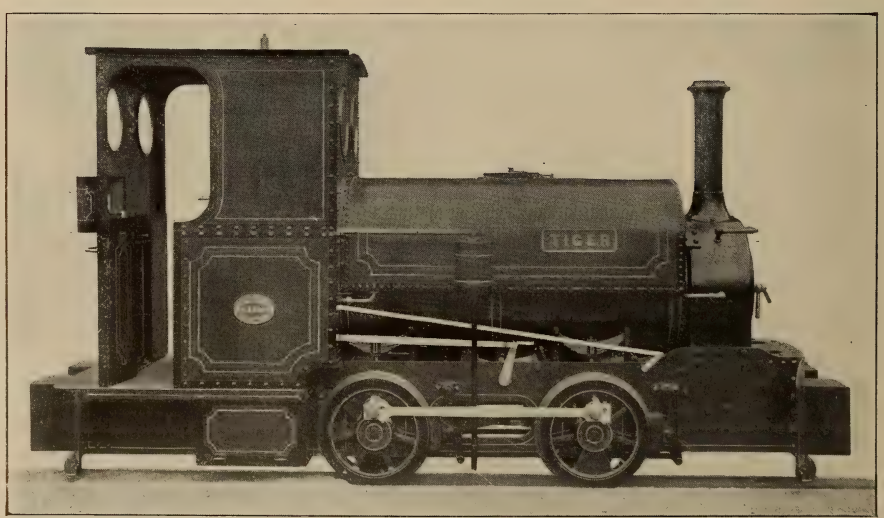


FIG 13.—AN INSIDE-CYLINDER LOCOMOTIVE BUILT BY THE HUNSLET ENGINE COMPANY, LTD.

ticeable similarity in the general appearance of engines, although they may differ considerably as regards dimensions, and it is, as a rule, possible to identify a Peckett engine at a glance. In the case of no other firm are the individualistic characteristics so pronounced, though the work of most firms can be easily distinguished.

The engine illustrated is, as stated, very large and powerful, and weighs, in working order, about 31 tons, and with cylinders 15 inches in diameter with a stroke of 21 inches, it is capable of performing very heavy work. In the case of smaller Peckett engines, the steam dome is generally lower than that illustrated, and is fitted with direct spring-loaded safety valves.

As an example of the supply of large contractors' locomotives to railway companies, Fig. 4 shows a saddle tank four-wheeled engine built by Messrs. Andrew Barclay, Sons & Co., Ltd., of Kilmarnock, for use on the Caledonian Railway. Some of the fittings are in accordance with standard Caledonian practice, but in most respects the engine is built to the builder's designs.

Fig. 5 represents a four-wheeled engine of medium dimensions built by Messrs. Hawthorn, Leslie & Co., Ltd., of Newcastle-on-Tyne. Fig. 6 illustrates a four-wheeled engine of average size built by the Hunslet Engine Company, Ltd., of Leeds. It weighs about 15½ tons in working order, and it can traverse with ease curves of 45 feet radius, and is adapted for working on light rails.

Fig. 7 shows a small four-wheeled engine adapted for 36-inch gauge tracks, built by Messrs. Hudswell, Clarke & Co., Ltd., of Leeds. In this engine the fire-box shell is raised to provide additional steam space about the inside fire-box. It weighs only about 9½ tons in working order, but is guaranteed to haul 84 tons besides its own weight on a gradient of 1 in 100, or 168 tons on the level.

In Fig. 8 an interesting engine is shown, recently supplied by the Avonside Engine Company, of Bristol, to the Lords of the Admiralty for service in Ascension Island on 36-inch tracks. This engine is able to deal with considerable loads, up to 240 tons on the level. It is adapted for wood burning, and is, therefore, fitted with a spark-preventing dia-

FIG. 14.—A WOOD-BURNING ENGINE BUILT BY THE HUNSLET ENGINE COMPANY, LTD.

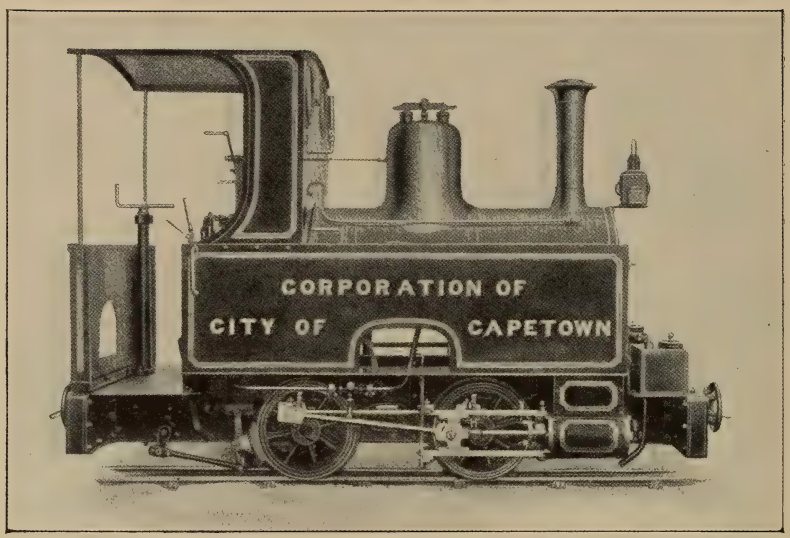


FIG. 15.—A SMALL FOUR-WHEELED SIDE-TANK LOCOMOTIVE BUILT BY MESSRS. ANDREW BARCLAY, SONS & CO., LTD., KILMARNOCK

mond stack. In this case, the wheels are arranged between the frames, the connecting and coupling rods being attached to outside cranks.

Fig. 9 shows a representative four-wheeled saddle tank engine built by Messrs. W. G. Bagnall, Ltd., of Stafford. This firm is largely associated with the construction of light and portable railway material.

A powerful four-wheeled engine built by the Brush Electrical Company, Ltd., of Loughborough, for the Whitwich Granite Company, Ltd., is shown in Fig. 10.

So far the engines described have been of fair size, and comprise similar features to a great extent. Only selected photographs have, however, been reproduced, though all firms mentioned build engines of practically every class and type so far mentioned. In addition to these firms may be added the names of Messrs. Kerr, Stuart & Co., Ltd., of London and Stoke-on-Trent; Messrs. Manning, Wardle & Co., Ltd., of Leeds; the Lowca Engine Works, Ltd., of Whitehaven; the Yorkshire Engine Company, Ltd., of Sheffield; Messrs. T. Green & Sons, of Sheffield; Messrs. Davies & Metcalfe, Ltd., of Manchester; and a few other firms. Besides these, all the firms usually associated with the building of large engines, such as the North British Locomotive Company, Ltd., of Glasgow; Messrs. Beyer, Peacock & Co., Ltd., of Manchester; Messrs. Robert Stephenson & Co., Ltd., of Darlington; the Vulcan Foundry, Ltd.; Messrs. Kitson & Co., Ltd., of Leeds, also build many small engines of contractors' types.

Several other interesting four-wheeled engines are shown in Figs. 11 to 14, inclusive. Fig. 11 shows a cheap but reliable design of small narrow-gauge engine built by Messrs. Kerr, Stuart & Co., Ltd. Fig. 12 illustrates a small four-wheeled engine adapted for 18-inch gauge tracks, built by the Hunslet Engine Company, Ltd. This engine weighs only $5\frac{1}{4}$ tons in working order, and can work on 20-pound rails with curves of 45 feet radius. Small water tanks are located between the frames. Fig. 13 shows an inside cylinder engine built by the same firm; and Fig. 14 illustrates a powerful wood-burning engine.

To be concluded in the February number

TELEGRAPHICA FROM VARIOUS SOURCES

By Wm. Maver, Jr.

ELECTRIC telegraphy was not introduced into the Kongo Free State, Africa, until about ten years ago; the telephone about three years later. There are now about 1500 miles of telegraph and telephone wire in operation in that country. Long-distance telephony is carried on between Kwamouth and Matada, a distance of nearly 400 miles. Wireless telegraphy is now being experimented with and, it is said, successfully.

There is quite an incentive to the use of wireless telegraphy in that country, owing to the difficulty experienced in maintaining the overland wires intact. Besides, the telegraph and telephone wires are frequently made useless by atmospheric disturbances during the daytime. It is said, however, that the greatest enemies to the land lines are the wild animals and the natives, the latter pilfering the copper wires whenever the opportunity offers itself. In numerous instances the wires are suspended on trees, and to avoid attracting the attention of the natives, the wires and the insulators are painted black.

The first line of telegraph in Persia was established in 1862, after much opposition from the priests, who denounced it as being closely allied to evil principles, and subversive of religion and the best interests of the State. But this opposition was gradually overcome and the presence of the telegraph in that country is now regarded with indifference by the priests. To-day there are about 1100 miles of pole line and 3300 miles of wires and 86 telegraph offices in Persia. An important line now extends from London to Teheran.

Telegrams in Persia are usually restricted to 10 words, for which the charge is $2\frac{1}{2}$ krans (15 cents). The cost of the telegram itself is only 12 cents, 3 cents being charged for the blank upon which the message is written. Messages of over 10 words are charged for at the rate of 12 cents per 10 words. This rate covers messages to all parts of Persia.

The yearly receipts of the Persian telegraph system are about $7,500, and the expenses of operation and maintenance about equal the income. One reason for this condition of affairs is that up to a few years ago fully 50 per cent. of the telegrams were transmitted gratis. Officers of the government, priests, lawyers, relatives of the operators, and everyone who could give a good or bad reason why his messages should go free, were on the free list. Attempts have been made to reform this condition, but owing to the influential positions held by those who enjoy the privilege of free telegraphy, progress in this direction is slow. Very few press messages are sent by telegraph in Persia, the rather quaint reason given for which is that the newspapers rarely contain information of sufficient importance to be sent by telegraph.

The first telegraph line in Japan was established in 1869, between Tokyo and Yokohama. The first telegraph system used was the well-known Breguet dial, or alphabet telegraph, which, owing to the simplicity of operation of the apparatus, was also much employed elsewhere before the advent of the telephone. Indeed many alphabet telegraph instruments are still employed in the railroad and commercial telegraph serv-

ice in different parts of Europe.

The instruments at the transmitting and receiving stations of the alphabet telegraph system consist of a dial, around which the letters of the alphabet are placed. To send a message, the transmitting operator moves a pointer around the dial and pauses momentarily at a desired letter. This action sends to the line a certain number of electrical pulsations. A needle at the receiving dial is moved by electromagnetic devices a corresponding distance and stops at the same letter. The receiving operator notes this letter, and in this way words are easily spelled out.

Besides being inherently a slow sending system, however, the mechanism of the dial telegraph is somewhat complicated and consequently rather difficult to keep in proper working order; hence it is not strange that in a progressive country, like Japan, it was ultimately superseded by the Morse telegraph system, the ink register of that system being at first used as the receiving instrument. More recently the Morse sounder has been introduced in that country.

There are now in operation in Japan about 850 telegraph circuits, of which 90 are worked duplex and 10 are worked quadruplex, the remainder being worked on the ordinary simplex Morse sounder system. The simplex circuits are operated on the "open-circuit" plan and, as a rule, current is supplied by Daniell cells. In Canada and the United States the Morse closed-circuit method is employed exclusively, and, with but few exceptions, current for the circuits is supplied by dynamo machines or storage batteries. In Great Britain also, and in the larger cities of Japan, storage batteries are supplanting the primary batteries.

There are now about 20,000 miles of land telegraph lines in Japan and about 85,000 miles of wire. The total number of paid telegrams transmitted over these lines annually is about 17,000,000. Messages are transmitted in Japanese letters and in Roman letters. The charge for telegrams in Japanese letters is 10 cents for 15 letters or less. For every 5 additional letters or less, 3 cents are charged. Messages written in Roman letters are charged for at the rate of 12 cents for 5 words or less, the charge for additional words being 3 cents per word.

The alphabet of the Japanese written language consists of about fifty letters or letters and syllables. For telegraphic purposes these letters, as well as the numerals, are represented by dots and dashes corresponding to those of the Morse telegraph alphabet. As there are about twice as many letters in the Japanese as in the English telegraph alphabet, it is evident that the combinations of dots and dashes necessary to represent all of the letters of the Japanese alphabet must result in a slow-speed alphabet telegraphically considered.

In the Morse telegraph alphabet the letters that occur most frequently are alloted the least number of characters. Thus the letter *E* is alloted one dot; the letter *I*, two dots; *S*, three dots; *A*, one dot and a dash; while the less frequently used letters, such as *Q* and *J*, are assigned three dots and a dash, and two dashes and two dots, respectively.

The time taken in making a dot is technically termed a time unit; the time of making a dash equals three time units; while the space between the Morse characters of a letter also equals one time unit. Hence in making the letter *E* one time unit is occupied, and the time consumed in making or transmitting the letter *J* of the American Morse alphabet is thirteen time units. In a Morse alphabet containing fifty letters or symbols, it is probable that the longest letter would consume about thirty time units in its transmission.

In view of the fact, however, that many of the characters of the Japanese alphabet are syllabic, it is to be assumed that their greater expressiveness may compensate somewhat for their greater length. This may

readily be understood by taking an example in the English language. Thus, if the word "stable" were represented telegraphically by characters denoting the syllables "sta" and "ble," it is clear that the characters of the symbols representing these syllables might not much exceed in length the Morse characters representing the six letters of the word in the English language. It has been calculated by the Japanese telegraph officials that 3.65 Japanese letters are equal to one English word of 4.67 Morse letters, and that consequently one Japanese Morse letter corresponds to 1.28 Continental Morse letters.

It is fairly well known that any one who has occasion to use the cable may have a registered cable address, consisting of one word, which will suffice to indicate the recipient's name and street address to the cable company. These addresses are registered in a book kept for that purpose in the cable offices, and upon receipt of a cablegram bearing a registered address a clerk refers to the register and adds the address to the message, gratis.

It is not generally known, perhaps, that this system has been extended by means of what is termed a reversible registration address, which has been in vogue for some time between the United States and those countries with which the Postal Telegraph and the Western Union Telegraph Company have direct cable communication. This reversible registered address serves the purpose of imparting to the recipient of the cablegram the name of the sender without requiring payment for a signature.

For example, if the banking house of Smithson, Jones & Company, New York, have an agent named Brown in London, the reversible address "Sonbrown," might be selected, and registered in New York and in London. A message arriving in either city addressed to "Sonbrown" would be delivered to the registered address, the cable clerk first adding the signature "Sonbrown," which would indicate to the recipient the origin of the message. No charge is made by the cable companies for this additional service and information.

A rather curious instance of inconsistency in telegraph rates was discovered recently by a tourist. En route to Montreal from New York, he telegraphed from Albany to Montreal a 10-word message for which the charge was 40 cents, the distance between those cities being 241 miles. The tourist farther along in his journey sent another similar message from Port Kent, on Lake Champlain, 86 miles from Montreal, for which telegram the charge was 25 cents. It developed, however, that before this message could reach its destination, Port Kent had to send it first to Albany, whence it was repeated to Montreal. Thus, while Port Kent was telegraphically 155 miles farther from Montreal than Albany, the rate was 15 cents lower.

In the Kamerun country, in Africa, the various tribes employ an instrument termed the elliembec, for the purpose of telegraphing information from one point to another. The instrument consists of a hollow gourd over the end of which a kid skin is tightly stretched. By some form of code signals, known only to the natives, messages are tapped out on the elliembic to distances of from 3 to 5 miles. This telegraph system is not employed for general communication, but is reserved for the use of the chiefs mainly to give information of threatened invasion or to obtain assistance from friendly tribes in times of emergency.

Current Topics

It seems to be a perennially growing fashion, among newspapers as well as men, to seek cheap scientific notoriety by taking up the cudgels in behalf of the metric system. Just now one of the large daily newspapers is hard at it, dishing out the same threadbare arguments that have done service in the metric cause for the past forty years, and reiterating in substance what those who are not in accord with it have heard until they are tired of it, that by opposing the change from the foot and the inch to the meter and the millimeter, from the pound to the kilogramme, and so on through the ramifications of the system, they are "severing themselves from the congenial sympathy of the enlightened public opinion of to-day." This phrase goes well with the scientific pap ladled out to each rising generation of readers by metrological reformers; but it means nothing to the engineer and manufacturer, who, to be successful, must be a merchant, too, and who knows too well how he stands to give up a practically useful system for the sake of any fanciful conformity with other countries. The foremost engineers of Great Britain and America, the best thinkers along common sense lines, unite in the opinion that there is no possible good to come to British and American engineering industries from adopting the metric system.

The most interesting engineering event of the past month, if, indeed, not of the whole year, was the arrival at New York, on her maiden voyage, of the turbine-driven Cunard Line steamship "Carmania,"—the forerunner of the two great 25-knot turbine liners of the same company, so much talked of during the past year and now approaching the launching stage. Particulars of this noteworthy ship are given elsewhere in this issue. Turbine-driven steamships, it is true, have been built before this. A number of them have been in English Channel service for several years; but these are of comparatively small displacement, and even the two larger turbine ships of the Allan Line, the "Victorian" and the "Virginian," are modest in proportions alongside of the 30,000-ton "Carmania." This is shown very

well, too, by a comparison of the machinery weights in these vessels, the low-pressure turbines, for example, in the Allan liners weighing only 78 tons each, whereas each low-pressure turbine in the "Carmania" weighs 340 tons. The advance in size made in this last-mentioned ship is thus seen to be remarkable.

The custom of bequeathing substantial sums of money to the uses of technical education has been growing apace of late years, and it is certainly an excellent one. The time has passed when the engineer was looked upon as a species of high-class mechanic, and it is a matter of much satisfaction that the world at large is gradually beginning to properly realize the professional nature of his calling. We do not for a moment undervalue a classical education for those who desire it, or whose tastes are out of harmony with the ways and means of applied science. Nevertheless, there is a growing conviction among great industrial executives that quite apart from the direct advantages of specialized technical training, there is perhaps no better preparation for a general business life than a good stiff four years' course in a modern school of engineering. Experience has shown that scientific education is not without its value in callings widely removed from engineering activity. One of the ablest of the younger present-day clergymen was first educated as a mechanical engineer with a special bent toward locomotive building, and the influence of his technical training imparts a breadth and sense of proportion to his virile work which twenty years of seminary life could not bestow. Important as artistic education and opportunity may be, one cannot help strongly desiring that as the years pass by, men of great wealth will provide more and more liberally for both technical education and scientific research, for, marvellous as the progress of the last hundred years has been, we are still not far from the threshold of nature's wonderful laboratory. Nor is it necessary to wait for men of Mr. Carnegie's generosity, for example, to give to such causes, before scientific progress can be made. The graduates of every engineering school have it within their power to benefit their Alma Mater in many other ways than by large money bequests,—by sending representative manufactured products to the college laboratory, presenting books and papers to the library, and in certain cases employing the professional staff and facilities of their school in research or testing work. It costs a great deal of money to educate a twentieth century engineer, but the expenditure is in all successful careers far outweighed by the ultimate benefit which the world receives through the development of great enterprises which bring to each citizen of civilized lands a higher and more effective standard of living.

One of the most interesting of recent presidential addresses before engineering societies was that delivered last month before the American Society of Mechanical Engineers by John R. Freeman. It was devoted to the safeguarding of life in theatres,—the practice and the art of fire prevention and protection,—and was so full of good advice and interesting comment that the temptation is great to give more space to its consideration here than the restricted space limits of this department ordinarily allow for any one topic. As one of the chief features of theatre fire risks, Mr. Freeman mentioned the astonishingly large amount of combustible material on a stage in connection with a great spectacular production. Referring to the Iroquois Theatre tragedy in Chicago about two years ago, Mr. Freeman stated that at the time of the

fire there were more than ten thousand square yards of canvas, or two and one-half acres, and in addition, about three thousand square yards, or half an acre, of gauze. To hang this required more than 10 miles in length of $\frac{5}{8}$-inch manilla rope, and in the frames, battens, braces, profiles and set pieces, the stage carpenter estimates there were about eight thousand square feet of white pine lumber. The total weight of this fuel was more than ten tons, all dry as tinder, and all set or hung in a way to give the quickest possible exposure and spread to the flames. It is a very rare case that so much scenery is found upon a stage, but if, as is more common, it were only one-fourth part as much, it is plain that the fuel supply is sufficient to send out an enormous volume of suffocating gas. Mr. Freeman computed that merely the quick burning of the gauze that hung over the Iroquois stage would heat a volume of air equal to that contained in the space above the proscenium arch to 1000 degrees Fahrenheit.

The main problem in the case of a fire under such circumstances,—under any circumstances, in fact,—is to give prompt and certain vent to the enormous volume of smoke and suffocating gas generated elsewhere than through the proscenium arch. The ordinary construction, with a high spacious chamber for the hanging loft above the level of the proscenium arch, makes it a simple matter structurally to keep this fire and smoke out of the auditorium, and no matter how great the mass of flaming scenery, a smoke vent of one-eighth or one-tenth the area of the stage, if instantly opened, would probably have saved all of the terrible suffocation that has occurred at the various large theatre fires on record. In a way, it has been long recognized there should be a large ventilator over the stage, and one city has copied from another the building law, that in the case of New York City reads as follows:—"There shall be provided over the stage, metal skylights of a combined area of at least one-eighth the area of the stage, fitted with sliding sash and glazed with double-thick sheet glass . . . the whole of which skylight shall be so constructed as to open instantly on the cutting or burning of a hempen cord . . . Immediately underneath the glass of said skylight, there shall be wire netting . . ." etc. The evident purpose of the thin glass is to cover the opening with something that will break out under heat if the mechanism for sliding the cover off fails. The wire netting is to catch any piece of broken glass from falling to the stage. The building law of the London County Council reads much the same, save that its ratio is one-tenth, and perhaps that is where the rule began.

The idea of a large ventilator expressed in these rules is all right, but the execution is commonly all wrong, and needs some good engineering to provide a design of damper with careful details that will be sure to work. Note the antiquated suggestion of the burning of a hempen cord, when fusible links have been used on the fire-doors in factories for twenty years! There is no good reason to expect the hempen cord in this position, in smoky atmosphere from which oxygen had been largely removed, to burn off until a majority of those in the gallery have been suffocated. In one of the newest and best of the New York theatres Mr. Freeman found the ventilator had a broad sheet of heavy canvas laced tightly across its opening with marline, because, as the stage carpenter said, the cracks around the ventilator let in too much cold air. No building inspector had objected, and the carpenter could not be made to see any danger. "It would burn off in any bad fire," he said. So it

might, but not until most of those in the gallery were dead. The requirement of thin glass in the building law is well meant, but it would be too slow in breaking out. The wire netting called for is a positive danger, as often applied.

Following the great Ring Theatre fire in Vienna, a number of years ago, a committee of the Austrian Society of Engineers built a model of the Ring Theatre on one-tenth of its lineal scale, which thus contained only one-one-thousandth of the cubic contents of the original, and made many tests and experiments. The experiments were divided into two groups, the first comprising those in which no ventilators were opened over the stage, while in each of the experiments of the second group two ventilators were opened, having a combined area which, according to the scale of their drawing, was very nearly one-tenth of the area of the stage. In the first series of tests made by igniting sheets of paper hung to represent the scenery, but containing proportionately far less combustible material than is often hung on a theatre stage, they found that the expansion of the air caused by the heat quickly forced the curtain outward from the proscenium arch, and within about 20 seconds from lighting the fire, this heating of the air produced an excess of atmospheric pressure, much greater than that of the ordinary pressure of city gas, thereby explaining why it was that the lights in the Ring Theatre became so quickly extinguished after the outburst of the fire. In the second series of these Austrian experiments, their models of the ventilating shafts were closed by sheets of paper, and as soon as these burned open, all excess of air pressure disappeared from the auditorium, and indeed, the updraught drew the proscenium curtain inward over the stage. During these experiments an unexpected warning was given against covering smoke vents by wire screens, for it was found that the bits of charred paper carried up by the draught almost completely closed them. To show how little this warning of the Austrian Society of Engineers has become incorporated in current practice, Mr. Freeman called attention to the building law of New York City, which requires that underneath all of these skylight openings designed as smoke vents, wire netting must be stretched, the law apparently never considering how quickly this will become so clogged as to destroy in large part the utility of the smoke vent. Shafts so screened by wire netting would, probably within a minute's time, be put into a condition of entire uselessness because of the fragments of burning cloth and embers with which they would be immediately covered under the strong updraught. The committee of the Austrian Society of Engineers concluded that the outburst of flame and smoke into the upper part of the auditorium and the extinguishment of gas lights in a theatre could all be prevented by providing adequate smoke vents over the stage, and placed these smoke vents as the feature of first import in safeguarding life in theatres, saying that without them emergency exits and fire curtains will be of no avail.

Automatic sprinkler equipment over the stage and throughout all rooms and nooks and corners, except in the auditorium, Mr. Freeman considers to be the second safeguard in the order of importance. A leading argument against automatic sprinklers has been the possibility that they would break open when there was no fire and thus injure the scenery. But there are statistics to show how extremely small this danger really is. The records show that out of a total of something over three million sprinkler

heads scattered through more than two thousand different factories, losses from premature discharge were occurring at the rate of about fifty sprinkler heads breaking open per year. This proportion of one sprinkler in each sixty thousand springing a leak per year, when applied to the conditions in a theatre that would commonly have less than one hundred and fifty sprinkler heads over the stage, although they were put in both under and over the gridiron and under the fly galleries, would give a probability at any one particular theatre of a leak over the stage once in four hundred years. Should we admit, which is not certain, that the danger of knocking one of these open by a blow is greater in the theatre than in the factory with its moving machinery? Suppose they break tenfold more often, it is plain that this danger of leakage is no just ground for excluding sprinklers from over a theatre stage.

Concerning the various dry powder fire extinguishers, much advertised at one time, Mr. Freeman said that the chief reason why these long tin tubes of powder have become popular is that they can be manufactured for about ten cents each, and that they retail as high as $3 each. They are nearly all composed of common bicarbonate of soda, frequently disguised by the admixture of a little cheap colouring matter, like Venetian red, and prevented from caking by the addition of starch. Mr. Freeman had samples of everything of this kind that he could find purchased in the ordinary channels of trade by different parties, and the respective groups of samples analyzed by three different chemists, in order to fortify himself against the possibility of wronging anyone through a mistake in the analyses, and had samples sealed up and retained for further analyses should anyone question his figures. Mr. Freeman had tests made of several of them and found them of doubtful value on even the smallest fires, and worthless for a fire in free ventilation. Generally considered he would recommend throwing them into the rubbish heap. Pails of water are, in his opinion, far more reliable.

On the other hand, the "soda water fire extinguishers," consisting of a copper cylinder containing two, three, or four gallons of a strong solution of bicarbonate of soda, with a bottle of acid at the top so arranged that it can be upset into the soda and water, thereupon generating a strong pressure by the evolution of carbonic acid gas, Mr. Freeman considered excellent for many situations where pails would be unsightly. As showing what people will pay good money for in the effort to get fire protection, he was interested in the story that one of his agents, a chemist, brought in about hand grenades. Mr. Freeman had purchased examples of some of the different kinds of hand grenade and had their contents analyzed. In the case of particular interest, the salesman offered, as proof of the superior merits of his compound, the statement that a quantity had just been purchased by the United States Government for the protection of one of the battleships. Analysis showed the contents to be simply water and common salt. Mr. Freeman saw a hand grenade of the same appearance, bearing the same label, in the model of the battleship at the St. Louis Exposition, so perhaps it is true that the United States Government purchased salt water at 50 cents per quart bottle for the fire protection of battleships.

There was a time when the locomotive designer used to judge the desirability of every detail entering

into the construction of his engine by its degree of simplicity. Within the past few years, however, the mechanism of the modern locomotive has become more and more complicated, and the machine as a whole has been made to bristle with fixtures of various kinds, no one of them simple, so that it may be well to refresh one's memory with the fact, emphasized some time ago by M. N. Forney in his characteristic forceful way, that in the adoption of locomotive improvements it is often easier to save coal than it is to save money. In other words, the cost of the devices for effecting the economy, and the expense of maintaining, may amount to more than the cost of the fuel saved. There is another consideration which should never be lost sight of, and that is that the prime purpose of locomotives is to haul trains on railways, and that anything which interferes with this in any way, by getting out of order, which lessens the amount of service which a locomotive will perform, is quite certain to be abandoned. A locomotive on a railway occupies a relation to it which a reaping machine, say, does to a farm. The prominent purpose of such a machine is to cut the grain when the harvest is ripe. Now, any device, no matter how useful, which will interfere with this purpose, at the critical period of harvest, is quite sure to be condemned and its use abandoned. On a railway, the delay of trains, especially when the line is crowded with traffic, interferes very seriously with the business of the road, and this becomes costly. Therefore any so-called improvement in locomotives which will lessen the amount of work which they can do in a week or a month or a year, is quite sure to fall into disuse. To save fuel alone is not a sufficient advantage to secure their general use. They must do this without materially increasing the other expenses or diminishing the amount of work the locomotive will do.

According to Sir William H. White in a valuable series of articles on submarines, contributed recently to the London "Times," the true conclusion with reference to such ships is that they are not and cannot be substituted for torpedo boats and destroyers, but are complementary to them. It may be doubted whether, on the whole, swift surface torpedo boats may not prove more effective than slow submarines in getting torpedo attacks "home" and injuring an enemy even in daylight. Great risks must be taken, no doubt, but the chances of escape seem to be greater than would be anticipated from *a priori* considerations, especially when attacks of torpedo craft are supported by other vessels of the fleets to which they are attached. A proposal which has been seriously considered and subjected to experiments, is the substitution for submarines of controllable torpedoes (such as the Brennan) operated from swift small vessels. In this manner the attack could be delivered from a considerable distance; the vessel from which the torpedo is operated would take up her position quietly, so as to avoid discovery, and at a distance where she would be difficult of detection, especially at night. Against ships at anchor such an attack should be successful, so far as the attainment of stationary targets by torpedoes is concerned, provided the vessel serving as a base was not injured seriously. As the result of trials it is claimed that similar success can be obtained against vessels in motion and rapidly changing their course; but only limited trials have been made.

European shipbuilders are beginning to recognize that Japan's dependence upon outside assistance for the construction of even her big ships of war is coming to an end. For some years the Japanese have been developing their resources, and it was well known that they had advanced sufficiently to enable them to con-

struct small cruisers and torpedo craft before the war with Russia began. They have, however, been building battleships and armoured cruisers of the largest type at the dockyards at Kure and Yokosuka for several months past. While they have had to obtain a large part of the material from other countries, they have been able to put it together almost entirely with native labour, and have shown great facility in the construction of guns and the manufacture of armour. Japan realizes the importance of making its progress sure if slow, and an arrangement was therefore made with Sir W. G. Armstrong, Whitworth & Company, under which a branch establishment of the English house will shortly be started in Japan. The ambition of the Japanese people for a long time has been to place themselves in a position of independence of outside aid. They proved apt pupils of the western world, and revealed a high standard of technique, and gradually they have been dispensing with the western labour which they employed during their years of tutelage.

CONSIDERING the state of development of Japanese shipbuilding for purposes of war, it is remarkable with what courage they have set to work upon the construction of battleships and armoured cruisers of the largest types. At Yokosuka they have under construction a battleship with a displacement of 19,250 tons, which is a greater displacement than has been attempted by any other navy heretofore, and as soon as this vessel is launched, a sister ship is to be laid down. There are already under construction at Kure, two armoured cruisers of 13,750 tons, and a beginning has been made with two even larger cruisers of 14,600 tons displacement. These large armoured ships mark a further development in the policy of concentration of fighting power in a single hull. In all of the battleships it is intended to mount four 12-inch, ten 10-inch, and twelve 4.7-inch guns, while the newest of the cruisers are to carry four 12-inch, eight 8-inch, and fourteen 4.7-inch guns. These are the first cruisers designed for any navy in the world carrying the same primary weapon as battleships. In fact, in gun power they will be superior to any battleship now afloat. The armoured cruiser of the light type is now disappearing.

THE navies of the future will consist mainly of battleships of two classes,—a heavy class, in which a certain amount of speed will be sacrificed for power of attack and defense, and light battleships which will have a speed of 23 to 25 knots, and somewhat lighter armament, but yet sufficiently heavy to enable them to take their place in line of battle, and to deal effectively with any of the battleships of the present types. Another interesting point in these new Japanese ships is that they have definitely abandoned the light quick-firing gun, which has hitherto been regarded as sufficiently heavy for repelling torpedo attack. In British ships it has been the custom to mount 12 and 6-pounders for this purpose. In the late war the Japanese learned that these guns are too light, especially in view of a tendency to apply armour to the boilers and machinery of torpedo craft. They have decided that a most efficient gun for dealing with mosquito ships is the 4.7-inch gun, which fires a shell of 45 pounds with great rapidity, and is sufficient, if it happens to hit a torpedo or destroyer, to completely annihilate it.

THE apparent disadvantage of this change of policy is the increase in the weight of the armament, but at the same time it is realized that the 4.7-inch gun is a most valuable weapon for use against the upper works of

big ships, if in the course of a battle the opponents draw in to close range. One point in the construction policy of the Japanese which has occasioned considerable surprise in view of the action of the British Admiralty in entirely abandoning the construction of protected cruisers is the decision to continue building small protected ships. They have in hand three unarmoured cruisers of 4200 tons, which have machinery of the turbine type, and will probably give a speed of about 21 knots. No details as to the armament of these boats are yet available, but the opinion is very generally held that these ships are regarded by the Japanese as useful merely for the subsidiary purposes of a naval war, such as the attack upon commercial vessels and the making of reconnaissances during an action.

WRITING on steel making in the electric furnace in the Engineering Supplement of the London "Times," F. W. Harbord states that the electric furnace, even under the best conditions, is not a cheap melter, but as a refining furnace towards the end of the operation, when a very high temperature is required, it is far more efficient; it therefore seems probable that the future development of the electric furnace will be in combination with some form of continuous open-hearth process, in which molten pig iron is first converted into what we may term "molten scrap steel" in a gas-fired furnace, and then transferred in the molten state to the electric furnace for final purification. By this means the additional cost over ordinary open-hearth steel would be comparatively small, the melting and preliminary refining having been done in the gas-fired furnace, and the electric furnace being employed only to do the final refining at such high temperatures as those at which it alone is able to work most efficiently and economically.

WILLIAM BANCROFT POTTER

A BIOGRAPHICAL SKETCH

By J. R. Hewett

WITHIN the last ten years a great revolution has been witnessed in rapid transit, both as regards street railways and high-speed service of almost every known type. During that time William Bancroft Potter has been engineer of the railway department of the General Electric Company at Schenectady, New York, and its successful development is very largely due to his personality.

It may be in great part attributed to the fact that Mr. Potter has made it a hard-and-fast rule that every subordinate engineer in his department shall be given responsibility, and have certain work directly in his charge; and also that each individual shall receive in full the credit for any work he may individually accomplish. In this manner he has gathered around him a body of able men, who take the keenest possible interest in their work, with a knowledge that it will be appreciated.

It would involve considerable space to trace the long list of events, and the many works accomplished, which finally led to the recognition of any one man as head of a department where such ever-changing work is always in progress, and again, to record the originality displayed by a

master mind in overcoming early difficulties in apparatus now made perfect. Few things are more difficult to do correctly than to analyze the character of a successful man, and to determine the factors which have been predominant in gaining distinction for him. In the case of Mr. Potter, one factor stands out prominently among all others,—his marvelous ability to take a wholehearted interest in every work he touches, and the indefatigable energy he displays in converting crude conceptions into completed work.

Beyond Mr. Potter's actual engineering ability, he has throughout his life displayed much forethought and painstaking care in developing every factor which was likely to help him in his profession. He has recognized what so many able men have failed to conceive before it was too late, that the cultivation of friendship and the association with other engineers is a very real form of education,—a form of education from which experiences may be gained that are unprocurable in any other manner.

He was born at Thomaston, Conn., on February 19, 1863, and even in his early childhood displayed an intense love for anything mechanical, as is still evidenced by many mechanical devices constructed by him in his boyhood. This trend in character is the more remarkable, when it is called to mind that his ancestors were engaged in agricultural pursuits for generations, and that no member of his family had been an engineer. The Potter family first settled in Connecticut in the year 1645.

Mr. Potter himself spent the early years of his life on a farm, and received his first training at the village school. Between the ages of 15 and 16 he attended school during the winter months and worked in the Seth Thomas Clock Factory during the summer. By this time young Potter had fully made up his mind to be an engineer, and, with this object in view, he became apprenticed to Sawtell & Judd, of Hartford, Conn., with whom he served a term of four years. After the completion of his apprenticeship, he remained with them two years longer as an employee. During his apprenticeship he displayed marked ability in mechanical work, and it was nothing uncommon for customers to request that young Potter be sent to do their work.

The work undertaken by Messrs. Sawtell & Judd was mostly in the nature of repairing stationary and marine engines. It was while working on the repairs of engines in the Hartford electric lighting station that Mr. Potter's attention was first attracted to the advantages of adding a knowledge of electricity to his mechanical experience. With the forethought that is so essential in the successful engineer, Mr. Potter realized that the future of the steam engine would, in a large measure, depend upon the development of electrical machinery, and so he determined to study the construction and management of the dynamo. It is interesting to record that at this time it was his ambition to some day become the chief engineer of a central station, and that he worked consistently with this object in view. It was to accomplish this end that he went to the Thomson-Houston Company, at Lynn, Mass., with letters of recommendation, and it was in this way that he first met Mr. C. A. Coffin and Mr. E. W. Rice, with both of whom he was destined to be so closely associated in after years, not only in business, but in friendship.

Mr. Potter started work at the Lynn factory in the summer of 1887. Only six weeks elapsed before he was sent to Durham, N. C., and afterwards to Greensboro, Ga., where he started up electric light stations. From there he proceeded to Raleigh, N. C., to overhaul the electric light station at that place, of which he acted as superintendent for the succeeding eighteen months.

It was during this period that he saw a trolley car for the first time,—in Washington,—and determined that this was the work that he would follow. Accordingly he left Raleigh in the fall of 1889, and returned to Lynn, entering the shops there as a student in electric railway work. After three months he was again on the road in electric railway construction.

In the spring of 1890, he worked on such important undertakings as the West End Street Railway power station, at Cambridge, Mass.; the Utica railway, and the Saratoga street railway in New York State, and the Alamo electric railway, of San Antonio, Tex. In one of these undertakings, 8 miles of double-track railway had to be built, a power station erected, complete overhead trolley work installed, and twenty cars equipped, all in forty days. Mr. Potter was responsible for the entire electrical equipment. After successfully accomplishing this task, he returned to Lynn and entered the shops as an assistant to Mr. J. B. Cahoon in the railway engineering department, his first work being in connection with the development of the S. R. G. motor,—the first single reduction motor of the Thomson-Houston Company. He followed this class of work for some time under Mr. Cahoon, and also under Mr. I. F. Baker, remaining with them until Mr. W. H. Knight was appointed engineer of the railway department, when Mr. Potter continued as one of Mr. Knight's assistants.

It was then that Mr. Potter really entered the field of actively developing electric railway apparatus. He did much useful work in the development of circuit breakers, fuse blocks, switches for cars, lightning arresters, and protective devices for electric railway service.

It is only those who know the conditions of railway apparatus at that early date, and the new requirements that were constantly developed, due to the ever-increasing capacity of electric railway service, who can fully appreciate the value of his work and the originality he displayed in overcoming the difficulties met with at every turn.

At that time there was no problem of more vital importance than the development of a successful series-parallel controller for electric cars. Many able men had spent considerable time in trying to solve this problem, and although much that was useful was accomplished, none of the devices were satisfactory. The problem was assigned Mr. Potter, and the outcome of his work was the series-parallel controller as we know it to-day. This work was of immense value to the engineering world in general, and to the General Electric Company in particular, and the device proved beyond question the engineering ability of its inventor.

As a result of his success in this direction, Mr. Potter was put in charge of the controller work, as well as the switchboard work and other details of railway and power station construction. He went to Schenectady in 1894, with the transfer of the engineering force from Lynn. Mr. W. H. Knight resigned in the summer of 1895, and Mr. Potter was appointed in his place.

Up to that time his work had naturally been associated with details, but during recent years his time has mostly been spent upon the organization of an engineering department, the selection of men, and the determination of the best means and methods of facing engineering situations as they came to hand. None but those who are closely associated with engineering, both from its technical and financial point of view, can fully realize what is entailed in successfully accomplishing such ends.

As already mentioned, Mr. Potter fully appreciated the fact that association is a real form of education, and there are few men who have a

larger circle of engineering friends than he. He has also realized and taken advantage of the fact that it is not only the association with men that is useful, but as perfect a knowledge as is possible of every piece of electrical or mechanical apparatus that is likely to enter into his work. Indeed, he possesses a knowledge that seems extraordinary, not only of electrical apparatus as a whole, but of the minutest details which determine the success or failure of the many devices used in railway work. He seems to possess an instinctive knowledge of mechanics, and can almost instantly distinguish between a good and a bad mechanical design.

It is this knowledge of both men and engineering subjects that has enabled Mr. Potter to be more than an engineer in the general acceptance of the word, as he has displayed a faculty for meeting all situations, both engineering and commercial, to an extent that is rarely found in any one individual.

Such in brief is the history of one who has succeeded, and succeeded not through the influence of any man, nor by the power of money, but by an inborn ability, fostered by a tireless energy, and by an unrestrainable determination to carry to a successful conclusion any work he undertakes.

Tireless energy and natural engineering ability are qualities which have given Mr. Potter the rank of a genius. Once a piece of work is undertaken, he carries it to a successful conclusion, taking only the rest which the body absolutely compels. Indeed, the sleep which is necessary to support life appears to be his one limitation to ceaseless work.

Mr. Potter has made friends with all he has met. His friends, and his assistants and subordinates, not only respect and admire his genius, but regard him with affection as a man and as a friend. It is rare indeed to find one whose personality is capable of inspiring such an interest in work, such a desire to succeed, such newborn energy, and it is these factors which largely account for Mr. Potter's success in life.

It is interesting to note that Mr. Potter has taken out over one hundred patents, covering a very large variety of devices. He is a member of the American Society of Civil Engineers, the American Society of Mechanical Engineers, and the American Institute of Electrical Engineers.

In addition to these he is a member of the Engineers' Club and the Transportation Club, both of New York City.

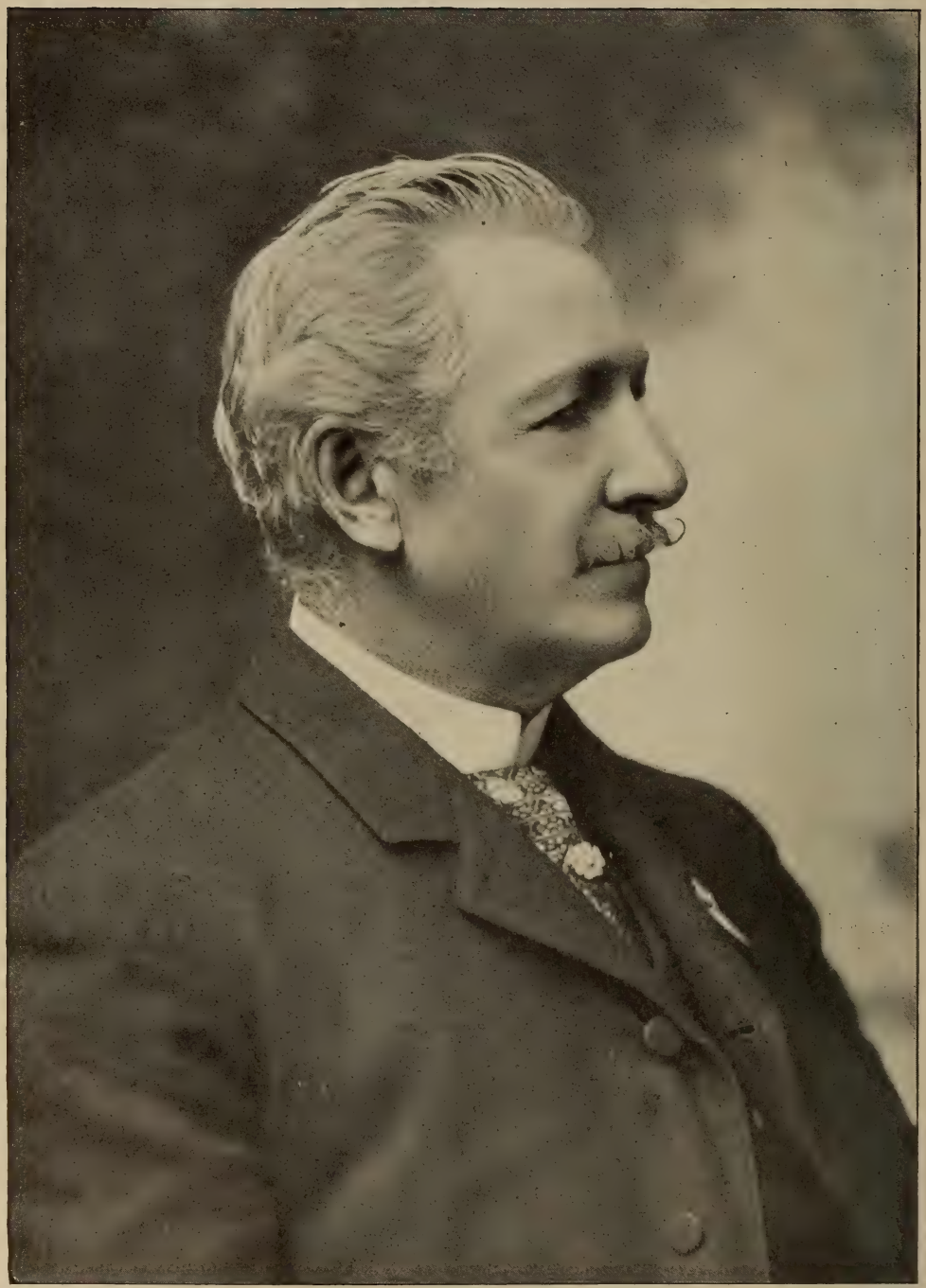


PHOTO BY WHITE, NEW YORK

CHARLES ETHAN BILLINGS

PRESIDENT OF THE BILLINGS & SPENCER COMPANY, OF HARTFORD, CONN.

SEE PAGE 352

CASSIER'S MAGAZINE

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RECENT AMERICAN CHIMNEY PRACTICE

By William Wallace Christie

THE number and character of the factory chimneys one can see in a town afford a good indication of the number and character of its industries. The building of a large number of chimneys, therefore, is a measure of the industrial growth of a country. Anyone who travels much is bound to be impressed with the great variety of types and design of these chimneys, and of some of them the writer proposes to treat in this article.

About six years ago a new company was organized to design and construct radial brick chimneys in the United States, only three of this type having previously been built in America,—one for Adam Weber, of Weber, N. J., 164 feet high, one for Carl Pruessing's Cement Works, at La Salle, Ill., 150 feet high, and one for the World's Columbian Exposition at Chicago in 1893, 80 feet high. All of these were ordered on the Continent of Europe. Since then a fad in engineering seems to have been radial brick chimneys, until reinforced concrete was well established, and just now the concrete-steel chimney seems to be the fashion. The first of this type to be built in America was for the Pacific Coast Borax Company, at Bayonne, N. J.,

THE INDIA MILLS CHIMNEY AT DARWEN, LANCASHIRE, ENGLAND. SEE PAGE 279

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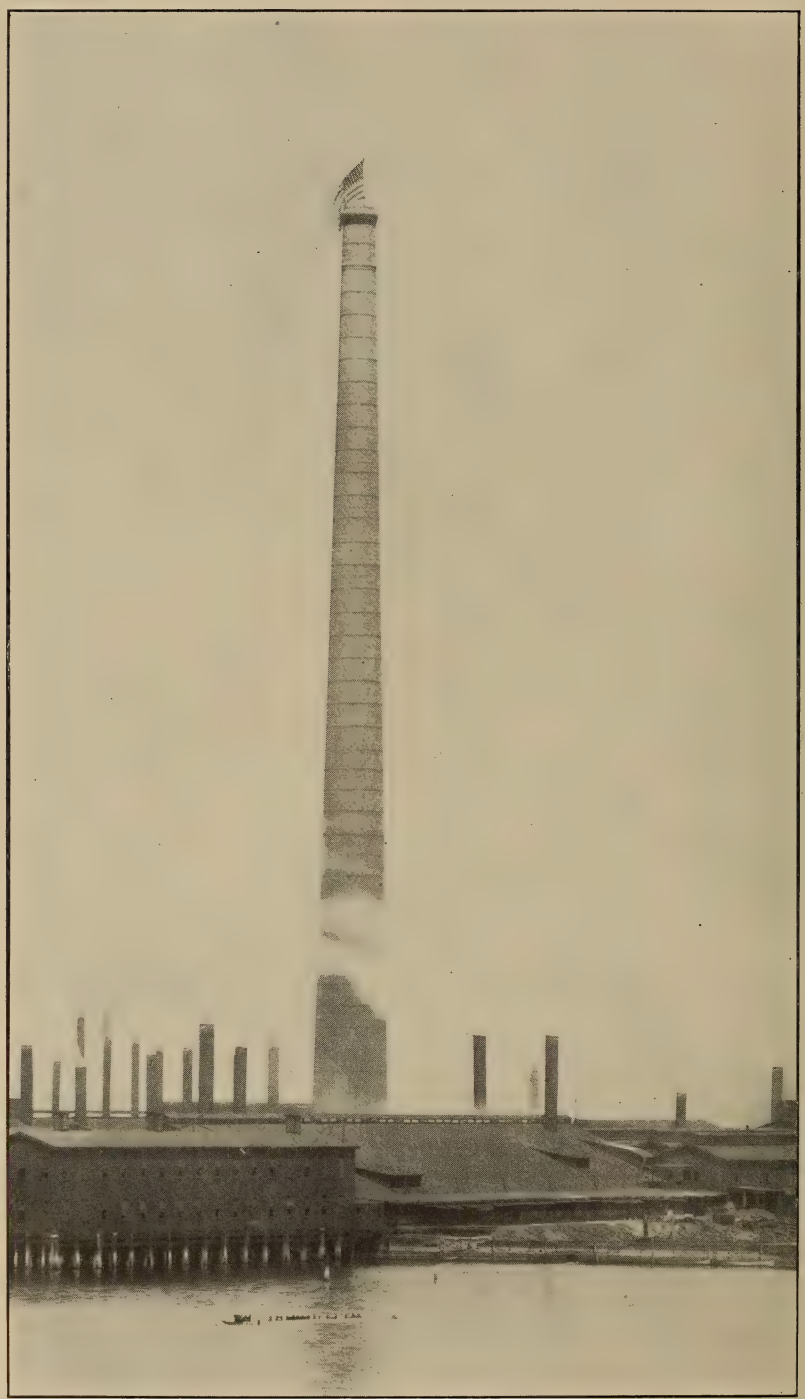
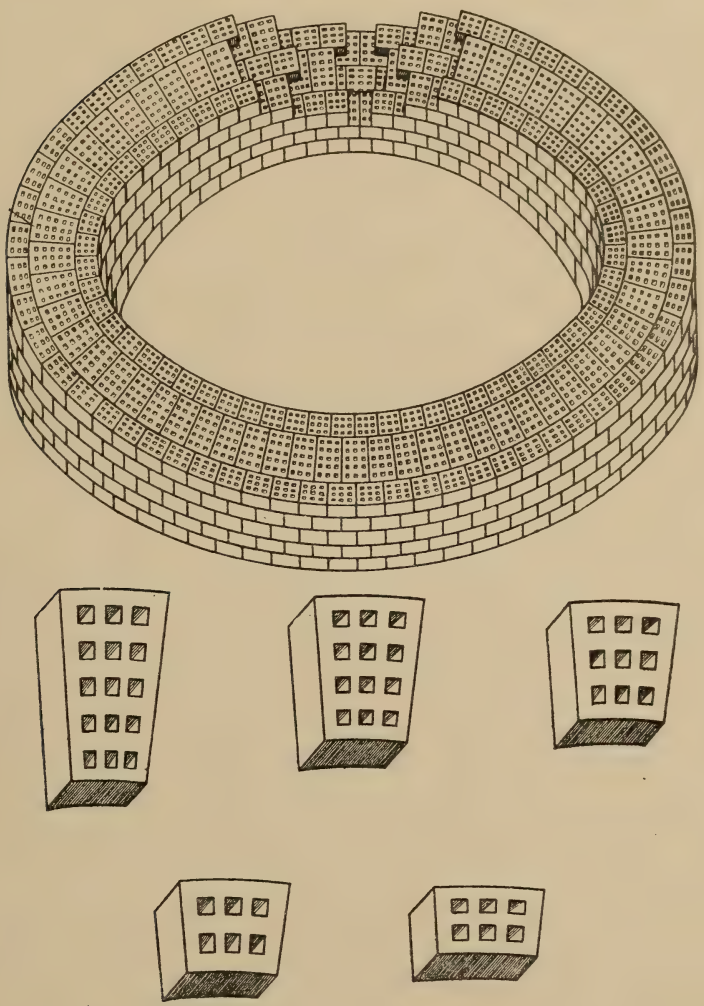


THE CHIMNEY OF THE ORFORD COPPER COMPANY AT CONSTABLE HOOK, N. J., BUILT BY THE ALPHONS CUSTODIS CHIMNEY CONSTRUCTION COMPANY, NEW YORK. THIS IS THE LARGEST RADIAL BRICK CHIMNEY IN AMERICA. HEIGHT, 365 FEET. INSIDE DIAMETER AT BASE, 20 FEET. INSIDE DIAMETER AT TOP, 10 FEET

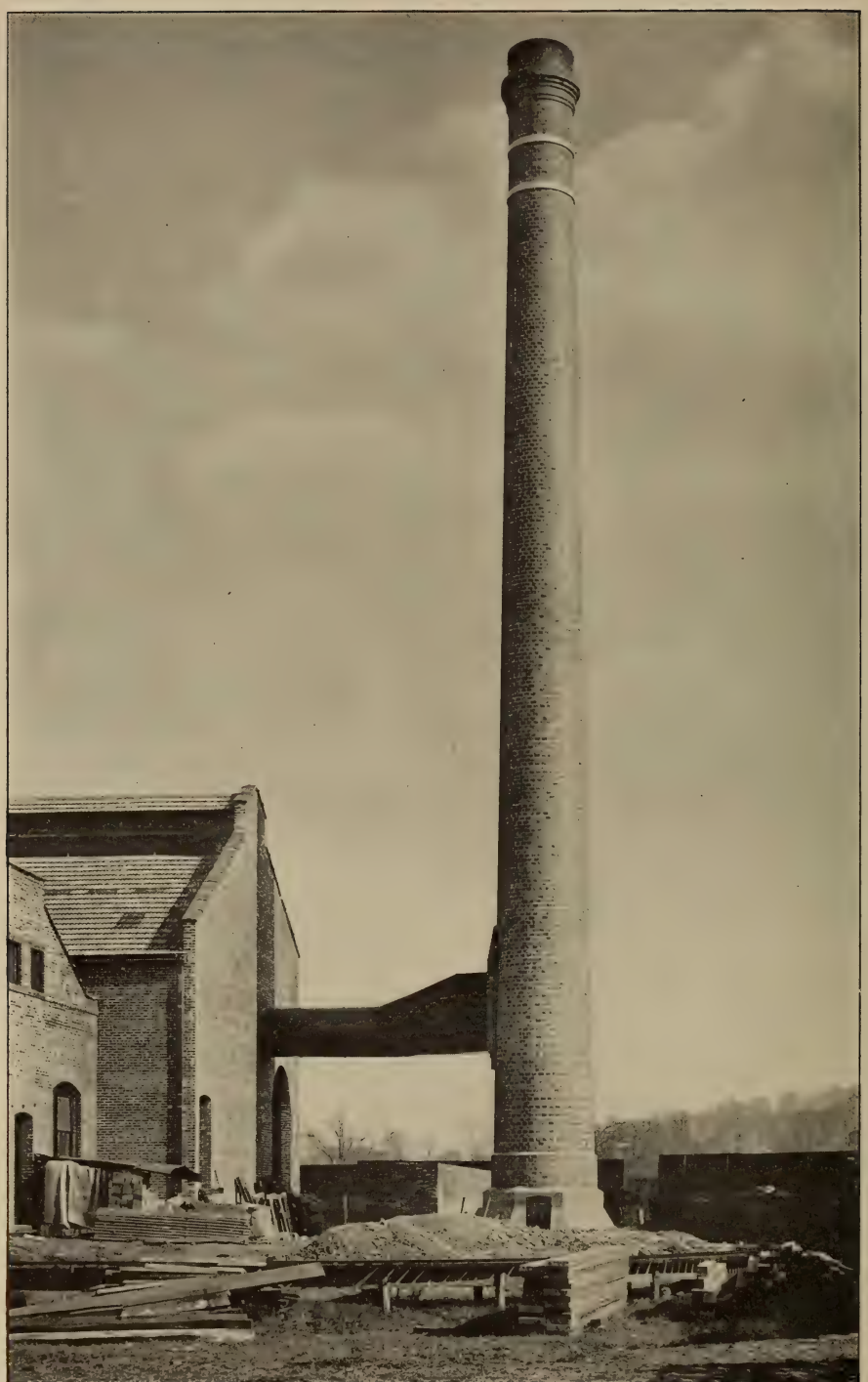


PERFORATED RADIAL BRICKS MADE BY THE ALPHONS CUSTODIS CHIMNEY CONSTRUCTION COMPANY, NEW YORK

150 feet high, and 7 feet inside top diameter of flue, built on the Ransome system. During these years, however, the old long-established types did not lose their hold, the largest brick chimney in the United States being built in 1899 in the city of New York, and there are now building at New Orleans, La., two self-supporting steel chimneys, lined, the highest of this type in the country.

The Metropolitan Street Railway Company have built at New York City the largest chimney in America, as regards both diameter and height. It is 353 feet high above the ground level, and has an inside flue 22 feet in diameter. The foundation is of concrete, 88 by 85 1-3 feet, 20 feet thick, and is laid on 1300 piles 40 feet long. The concrete was made of one part of Giant Portland cement, three parts of sand and five parts of broken stone.

This is a double-shell chimney. Starting with a base 55 feet square, each corner is cut off 4 feet 5 inches back from corner up to the 85-foot level, above which it is circular in



RADIAL BRICK CHIMNEY OF THE PATERSON PARCHMENT PAPER COMPANY, PASSAIC, N. J. BUILT BY H. R. HEINICKE, INC., NEW YORK

section. The outer shell is 28 inches thick up to 60 feet elevation; from 60 to 150 feet it measures 24 inches; from 150 to 200 feet, 20 inches; from 200 to 280 feet, 16 inches, and from 280 to 323 feet, 20 inches, above which is the very heavy cap masonry.

The inner shell extends to within a few feet of the top and is 20 inches thick up to the 120-foot level; from 120 feet to 160 feet it is 16 inches thick; from 160 feet to 250 feet, 12 inches thick, and from 250 feet to 341 feet, 8 inches thick. The chimney has a vertical separator 12 inches thick, of red brick, carried upward to the 85-foot elevation; this is intended to make two chimneys of the one shaft, each half having three flue inlets, placed one above the other. The chimney is amply equipped with lightning rods, which are not required on steel chimneys.

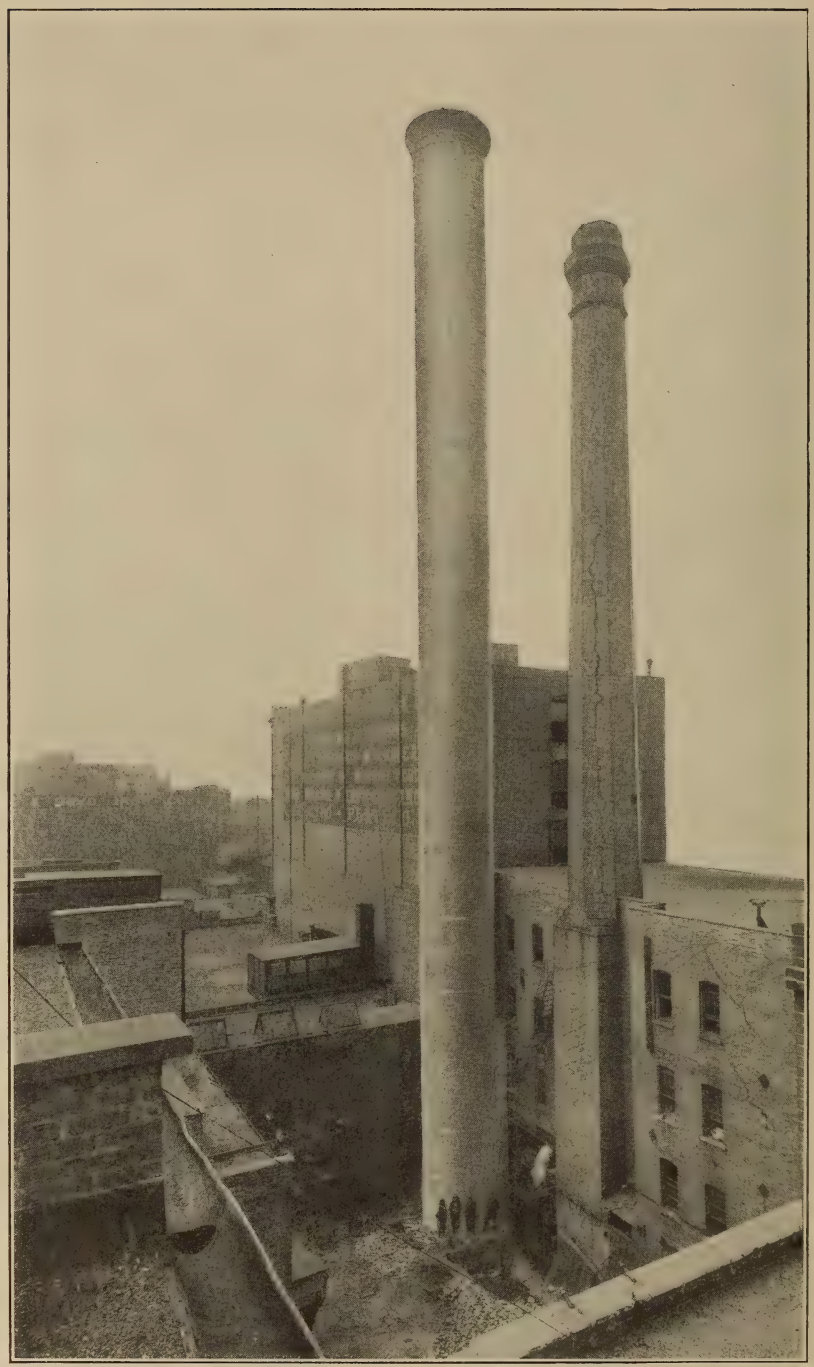
The calculated weight of the entire chimney is 19,804 tons, or 2.63 tons per square foot at the bottom of the concrete base. The horse-power of this chimney, according to the author's rating, is 23,164 H. P. Its cost was approximately $120,000, which is $5.18 per horse-power.

A 200-foot red brick chimney, 8 feet in diameter inside of flue, designed by the writer, with only one shell, but lined at the base with firebrick, had a bearing weight on the earth of 1.164 tons per square foot; at the base of the brickwork of 89.3 pounds per square inch; wall thickness, 42 inches at base; 13 inches at top.

In the Metropolitan chimney previously mentioned, the outer shell exerted a pressure of 49 pounds per square inch at the base of the brickwork; at 20 feet elevation it is 128 pounds per square inch.

At the Montrose Pumping Station, at Allegheny, Pa., two chimneys were erected, one on either end of the boiler house. In this way symmetry was obtained. The exterior of these chimneys was made similar to a wooden or stone column, with a heavy moulded base, on a square

WEBER STEEL-CONCRETE CHIMNEY OF THE AMERICAN SMELTING AND REFINING COMPANY TACOMA, WASH.—SEE PAGE 275



CONCRETE-STEEL STACK, 275 FEET HIGH, RANSOME SYSTEM, BUILT FOR THE PLANKINGTON ESTATE, MILWAUKEE, BY MESSRS. A. MONSTED & CO., CONTRACTORS, MILWAUKEE

pedestal, but with a cap at the top similar to the design of a steel chimney cap.

Other high brick chimneys have been built in the United States, among them that for the power station of the Union Elevated Railway, at Chicago, Ill., octagon, red brick, 250 feet high, 10,000 H. P.; one for the Omaha & Grant Smelting & Refining Company, at Denver, Col., octagon, 350 high, 16 feet diameter flue, cost $55,000; one for Clark's Thread Works, at Newark, N. J., 335 feet high, 11 feet flue diameter, and one for the Narragansett Electric Company, at Providence, R. I., octagon, 260¾ feet high, 14 feet diameter flue.

The thickness of walls is much greater for red brick chimneys than for radial brick shafts. The wall thicknesses in concrete-steel chimneys, however, are less for equal dimensions of flue than in either the radial or the red brick chimneys.

RADIAL BRICK CHIMNEYS

Radial perforated bricks are made from a special quality of smooth clay, and when burned to a high heat,—much higher than used for red brick,—they are very similar to terra-cotta. The bricks are made with an outer face of about 4 by 6 inches, or slightly larger, and are hydraulically pressed. The outer face is enamelled with a dull finish in any colour to suit the owner of the finished chimney.

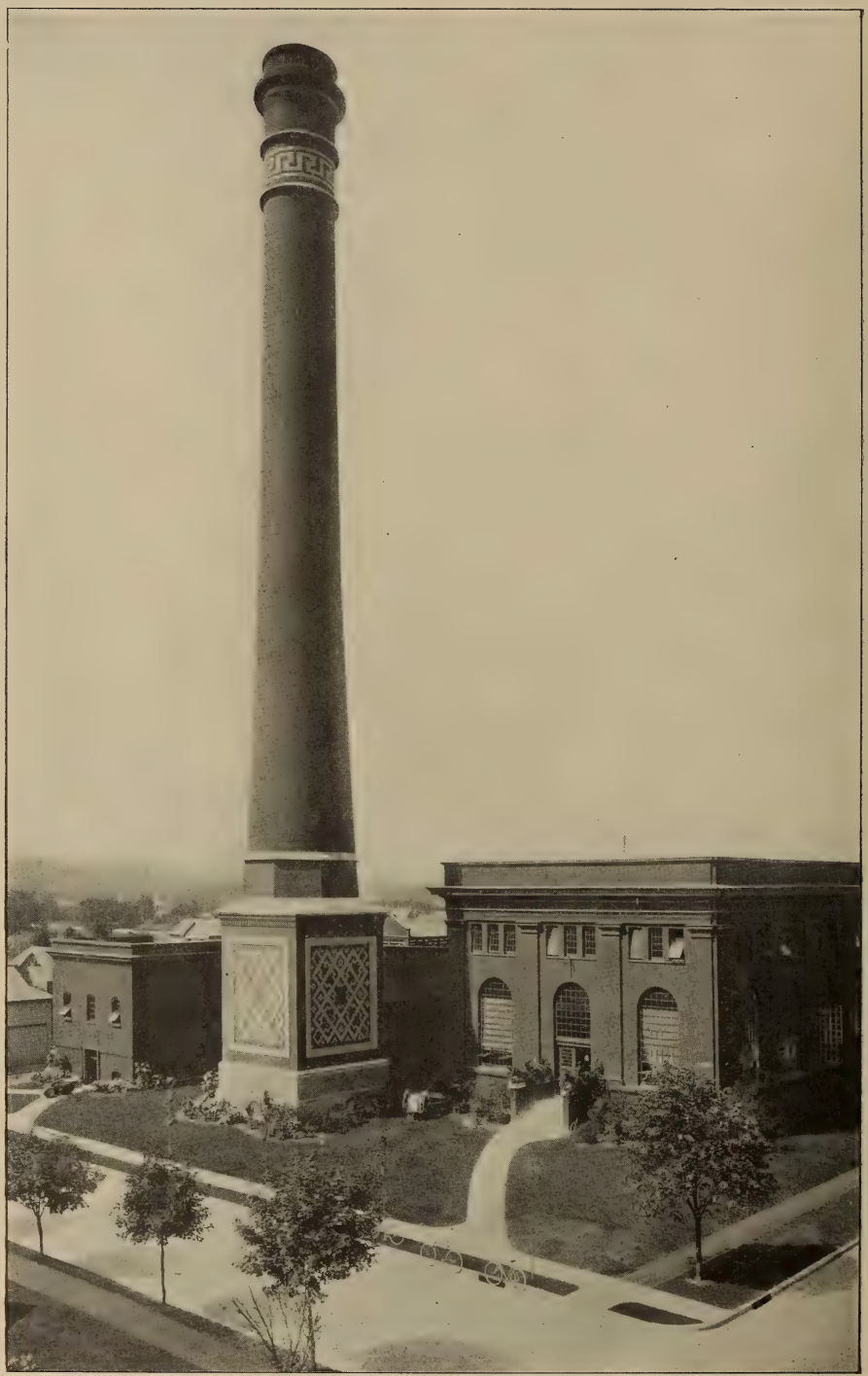
The sides of the brick are radii of the circle on which they are used, and the outer face is an arc of the circle. The large face gives less joints than we have in a red brick chimney, and is one of the factors in the good appearance which radial brick chimneys make.

From actual tests it appears that the adhesive power of cement mortar on perforated radial bricks is three times as great as on flat-surface bricks of the same clay. In the United States perforated radial bricks are used. Perforated bricks are also stronger in compression than solid ones of the same outside dimensions. The perforations are in a vertical direction and measure about 1 inch by 1¼ inch with an inch of clay between the holes, which go entirely through the brick. While we are told about the advantages of radial chimneys and their superiority to red brick chimneys, still the radial chimneys are almost without exception constructed of common red brick up to a height above the flue entrance from the boilers, which portion is made square or octagon-shaped.

A RANSOME REINFORCING BAR, USED IN THE SYSTEM OF THE RANSOME & SMITH COMPANY NEW YORK

The writer in designing a chimney for the Paterson Parchment Paper Company, at Passaic, N. J., insisted on having it built of radial brick for its entire height, with the result shown on page 270. The base and foundation in this case are Portland cement concrete, the top of the base being at the boiler room floor level. The height of this chimney above the floor level is 100 feet, and flue diameter, inside, 4 feet.

The largest radial brick chimney in America is that of the Orford Copper Company, at Constable Hook, N. J. It is 365 feet high, 10 feet inside top diameter, and 20 feet inside diameter at the base, above which the exterior is square for a height of 30 feet, this part being constructed of ordinary red brick. Above this, radial bricks are used, 4 inches thick on face. The circular shaft is 46 inches thick at the 30-foot elevation and 11 inches at the top. Iron bands of 5-16 by 3½-inch stock, are laid in



THE CHIMNEY OF THE NATIONAL CASH REGISTER COMPANY, AT DAYTON, OHIO, IS 175 FEET HIGH, WITH A UNIFORM INSIDE DIAMETER OF 6 FEET. IT HAS A DOUBLE SHELL, WITH A CAST-IRON CAP ON THE OUTER SHELL BUILT IN 1901

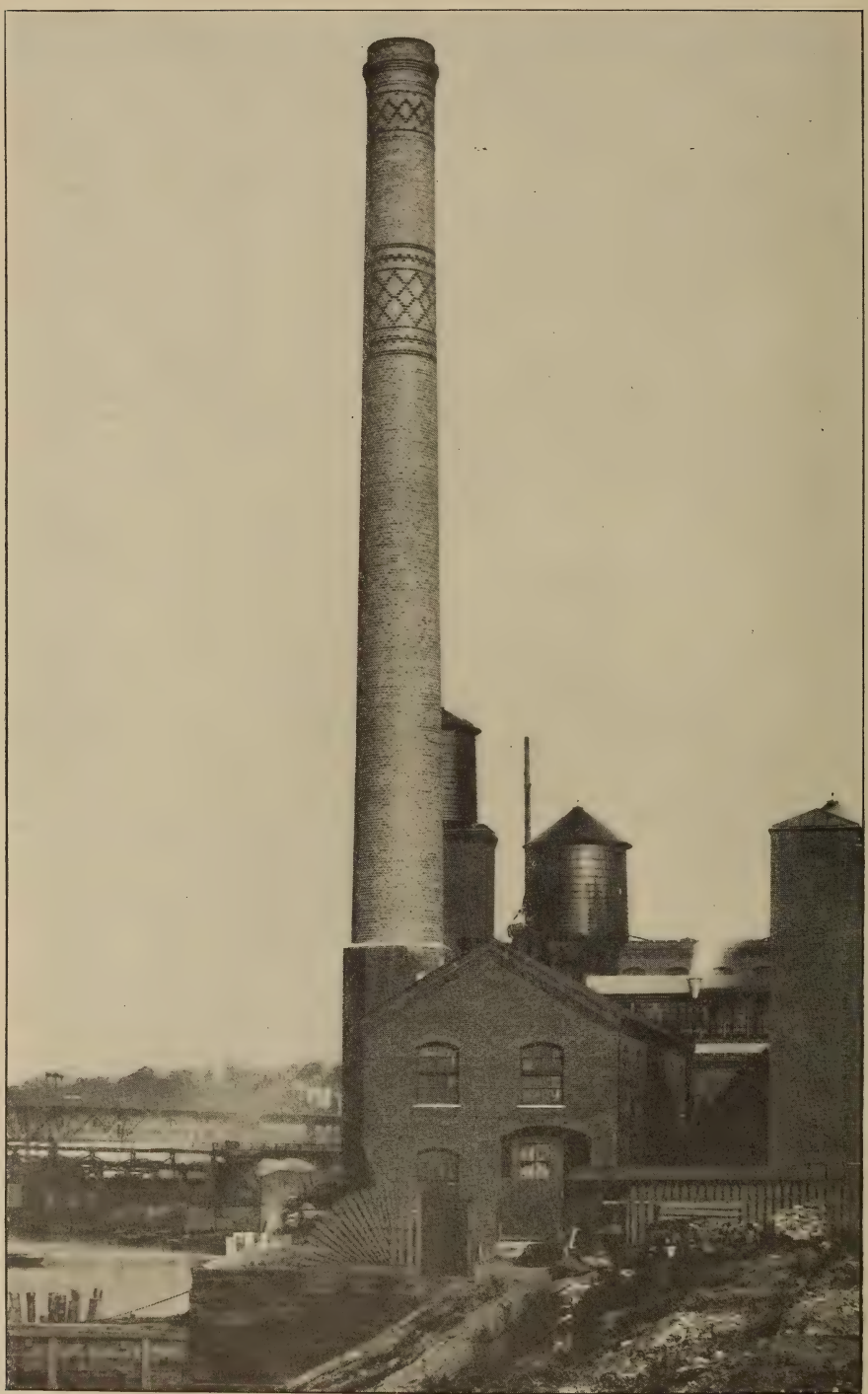
SELF-SUPPORTING UNLINED STEEL STACK OF THE NICHOLS COPPER COMPANY, LAUREL HILL, LONG ISLAND, N. Y. HEIGHT, 310 FEET. SEE PAGE 277

the walls, 8 feet apart. The lining of fire-brick is 42 feet high, in three sections, each being carried on corbels, and leaving an air space of two inches between it and the shell. Partitions like an X divide the chimney into four parts or flues.

Among other large radial brick chimneys may be mentioned one built for the Southern Electric Light & Power Company, at Philadelphia, 275 feet high, with 18 feet inside top diameter, shown on pages 278 and 279; four for the Manhattan Elevated Railway, at New York city, 278 feet high, with 17 feet inside top diameter; and one for the Newark Electric Light Company, 250 feet high, with 9½ feet inside top diameter.

CONCRETE-STEEL CHIMNEYS

The chimney for the smelting works of the American Smelting & Refining Company, at Tacoma, Wash., was built to carry off fumes and smoke from the operations of the plant, and from plans using the Weber system of steel re-enforcement. The chimney is 300 feet high above the ground; for 90 feet upward there is a double shell, 9 inches thick outside, 5 inches inside, with a 4-inch air space. The inner core is free to expand upward independently of the outer shell, above which is a single shell, 7 inches thick, extending to the top; the top is lead lined inside, 20 feet down and over the cap. The inside flue diameter for the entire height is 18 feet; the flue in-



A RADIAL BRICK CHIMNEY BUILT BY H. R. HEINICKE, INC., OF NEW YORK, FOR THE PHILADELPHIA RUBBER WORKS

let is 10 feet wide by 26 feet high.

The foundation is of concrete, 39 feet square by 6½ feet thick. The steel reinforcement of the Weber Steel-Concrete Chimney Company., of Chicago, consists of steel T-bars, set vertically and made fast to hoops of similar bars, set at regular intervals. In large chimneys the vertical bars have been 1¼-inch Ts, the hoops 1-inch Ts.

These vertical bars continue downward into the foundation concrete where they are secured to the network of T-bars laid across one another in the sub-foundation. The foundation concrete mixture in the case of the Tacoma chimney was one part cement, three parts sand, five parts gravel. The chimney shell concrete mixture consisted of one part cement, three parts sand.

The calculated weight of the chimney and foundation is 1659 tons, and the unit load per square foot of ground is 1.063 tons. The time required to build the chimney was 82 days, excluding Sundays only, and the cost was approximately $28,000. The horse-power of this chimney, according to the author's rating, is 14,312 H. P.; hence the cost was about $2 per H. P. This is the largest of this type now built.

Another chimney of this general class is that of the Pacific Coast Borax Company, Bayonne, N. J., built about 1898, and the general dimensions of this are 150 feet high by 7 feet flue diameter. This chimney has turned out very well and is in daily use. It was built with the Ransome system of re-enforcement. While the shaft has two shells, an outer and an inner one, joined together at the top, the Weber system uses two shells, an outer one and an inner one—a lining extending upward but a short distance and entirely independent of the outer shell.

Another tall chimney on the Ransome system is that at the plant of the Plymouth Cordage Company, at Elizabethport, N. J., which has an inside flue diameter of 8 feet 8 inches, and a height of 220 feet above the floor level. In the Ransome system the metal reinforcement is obtained by using a square bar of soft steel, twisted so much that the elastic limit of the steel is nearly reached. The number of twists given to a bar depends, of course, upon the strength and elasticity of the metal.

Hoops made of the twisted steel are imbedded in the concrete at varying intervals, according to the size of the chimney; vertical bars of the same material are also set in the concrete to take the tensile strains.

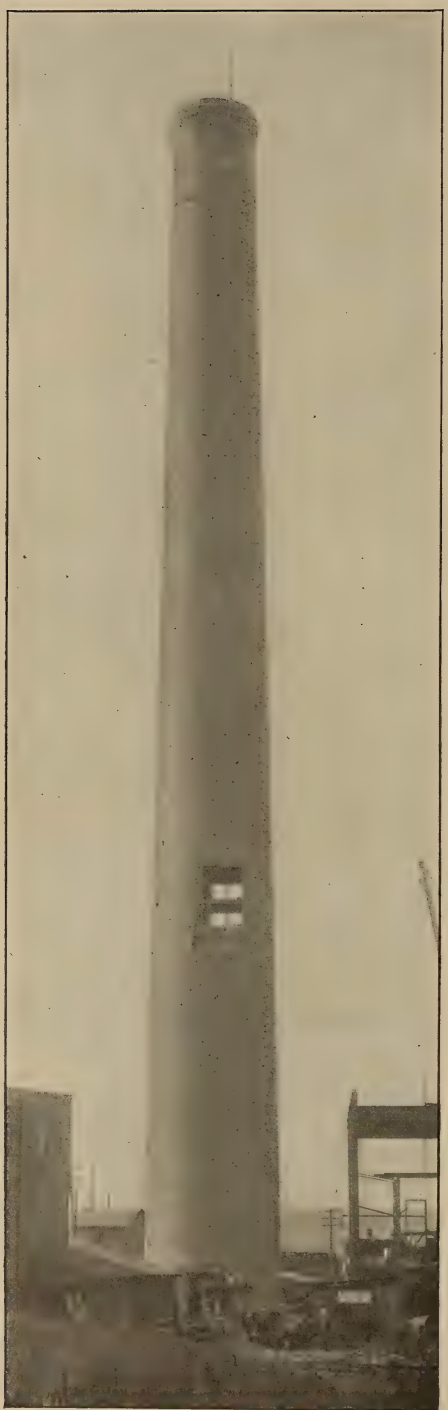
In a chimney with a flue 7 feet inside diameter and 150 feet high, ¾-inch square twisted bars were used,—as hoops, 2 feet apart, and as vertical bars 8 feet apart, in both the inner and outer shells, for the Ransome chimney is a double-shell chimney throughout.

THE STEEL CHIMNEY

This is the "made-while-you-wait" variety, and as such fills a great many orders. The best of this class to buy is the self-supporting steel chimney, lined for its entire height with brick,—fire-brick in the lower portions, and usually common red brick for the top portions.

The writer designed a lined chimney, which, however, was supported by guy wires, for a terra cotta plant, where the gases were known to have a temperature of at least 1900 degrees F. This is the most severe every-day condition as to heat which he has had to meet. This chimney was 7 feet in diameter by 150 feet high, and as far as he knows is the largest guyed steel shaft now in use.

The Nichols Copper Company, Laurel Hill, N. Y., have a chimney 310 feet high, which is self-supporting, and although it is built of steel, it is unlined. Painted with a special preservation coating both inside and outside, it was very carefully examined inside and outside after a few years' use, and the protection was found to be effective against corrosion. The temperature of the gases, however, is said to be quite low,—about 250 de-



CHIMNEY FOR THE SOUTHERN ELECTRIC LIGHT & POWER COMPANY, PHILADELPHIA. BUILT BY THE ALPHONS CUSTODIS COMPANY

grees F., or perhaps slightly higher.

The life of a chimney is as much a matter of the character of service in which it is engaged as the climate of the locality. A chimney in intermittent use will not last nearly as long as one in constant service, which remark applies especially to steel unlined chimneys.

Red brick chimneys are the longest-lived, and when well built are good for a hundred years. As to radial brick chimneys, they have scarcely had enough exposure to warrant an opinion on them; probably they have second place—their wall thickness is considerably less than that of the red brick ones. Next in order the writer would place the concrete-steel and steel lined chimney, which latter should be good for as long a life as the radial chimney if properly cared for.

The stability of a chimney is also a most important feature of its design. Each type has its own methods for making the shaft stable, and each contractor has his own way of doing things. Designers vary the factor of safety, or, as the writer would call it, the "factor of stability" to suit local conditions, materials, and their own ideas. In reality, the quality of the materials and the way the work is done counts for much more than mere juggling with figures, and religiously following them.

The horse-power given for each chimney in this article is based on the author's rating after the formula $H.P. = 3.25 A\sqrt{H}$, which rule and tables calculated from it and its modifications, are to be found in the writer's book on "Chimney Design and Theory."* For the various types approximately the following figures give the cost of large chimneys per horse-power:—

Red brick, double shell, $4 to $5.

Radial brick, single shell, $3.50 to $4.50.

Steel lined throughout, $3 to $4.

Concrete-steel, single shell, $2.

* Published by the D. Van Nostrand Company.

A LUNCHEON PARTY AT THE TOP OF THE 275-FOOT HIGH AND 18-FOOT DIAMETER CHIMNEY OPPOSITE

These costs include foundation. Cost, of course, depends largely on local conditions,—cost of labour and material,—and is subject to constant fluctuation.

One does not see very much ornamentation put on chimneys, but occasionally the character of the plant demands it. The Queen Lane Pumping Station, at Philadelphia, Pa., has such a chimney, also the power plant of the National Cash Register Company, at Dayton, Ohio, 175 feet high; 8½ feet inside diameter of flue throughout; double shell with a cast-iron cap on the outer shell. Probably the most ornamental of recent chimneys were the two at the Paris Exposition of 1900. The only marble-faced power plant chimney to the writer's knowledge is the circular one at the Mt. Royal Pumping Station, Baltimore, Md. Probably the richest and most ornamental of chimneys is one built in 1869 for the India Mills, Dorwen, Lancashire, England. It is 300 feet high, of red, white and black bricks. The foundation is 10 feet 6 inches deep. The base is of solid ashlar, 29 feet square by 42 feet high. The stone cornice of this base is 35 feet long on each side.

The shaft, 24 feet square, perfectly plumb on the outside, is built of bricks as above mentioned. The wall is 3 feet thick at the base cornice, reducing by offsets to 23 inches thick 255 feet above ground, where the main cornice starts. The large overhanging cornice cresting contains 20 tons of metal made in 300 and more castings, secured by slots and lugs, no bolts being used in the work.

This chimney also has an independent inner flue 180 feet high, which prevents injuring the outer shell by high temperatures.

HALF A DECADE OF PROGRESS IN ELECTRICITY AND MAGNETISM

By Dr. Edwin J. Houston

THE first half decade of the twentieth century has witnessed extraordinary progress in electricity and magnetism. While this progress has been more marked in some directions than in others, yet it is an interesting fact that there is scarcely any department of electricity, or of its sister science, magnetism, in which the progress has not been marked.

Without attempting either to follow a strict chronological order, or to include by any means all the important advances that have been made in this great field, it will be interesting to discuss, if only to some slight extent, some of the more striking of these advances.

It might be supposed, that in so short a time as half a decade, it could hardly be expected that very marked progress could be made in any department of human energy. It should be remembered, however, that now, at the beginning of the twentieth century, owing to the efficient mastery of the physical forces, man is placed under far different circumstances than those existing at the time of Methusaleh.

The wonderful improvements that have taken place in the speed with which man is able to diffuse his thoughts, as well as to transport his body and its attendant material comforts, have made it possible for one to actually live longer, so far as efficient progress is concerned, during a brief span of seventy years, than did Methusaleh in the nine hundred, three score and nine years of his life. In the olden times it took a large portion of a lifetime for the knowledge of any discovery or progress in one part of the world to reach distant countries. Now, however, it is not only possible to flash intelligence to the most distant parts of the world in the twinkling of an eye, but nearly all parts of the world are readily accessible to man.

THE FIRST ATLANTIC CABLE

It was a matter of great import to the progress of the world, when, in 1865, after repeated failures, beginning with the year 1857, Cyrus W. Field at last succeeded in laying the first successful Atlantic cable, thus placing the Continents of America and Europe in almost instant communication with each other. Although the cost of this great under-

taking, counting all the failures, reached the enormous total of about twelve million dollars, yet it was money well expended, and yielded, as far as the welfare of the world was concerned, a return many thousand fold its entire cost. There occurred, however, during the first half decade of this century, an event that is profoundly more significant to the world's progress than the laying of the first Atlantic cable,—namely, the successful bridging of trans-Atlantic space by wireless telegraphy. Allusion is here made to the three Morse dots that were first successfully transmitted across the Atlantic Ocean, from continent to continent, by Guglielmo Marconi, on December 12, 1901.

WIRELESS TELEGRAPHY

During the four decades that have passed since the successful laying of the Atlantic cable, wonderful progress has been made in the art of telegraphy, but, in no direction has this progress been so far reaching as in the case of the three now historic Morse dots that were successfully transmitted across the Atlantic, without wires, from a station at Poldhu, on the extreme southwestern coast of England, and received by Marconi at a station at St. John, Newfoundland. This achievement can properly be regarded as one of the most remarkable triumphs of the human intellect. It was a grand triumph of mind over matter. The invisible rays of electro-magnetic light were thus forced to reveal their presence to the cunningly devised contrivances placed in connection with the antennæ of the receiving apparatus. The prophetic utterance of Job, delivered many thousand years before,—"Canst thou send lightnings, that they may go, and say unto thee, 'Here we are?'" was fulfilled.

Thus was established a new and most potent method for diffusing man's thoughts and inventions throughout the space that surrounds the entire surface of the earth. Man has thus, to a certain extent, become practically ubiquitous, and is able to communicate, under proper circumstances, with his fellows, wherever they may be.

In view of the great importance of this achievement, it will be interesting to trace briefly the manner in which this pioneer experiment in wireless telegraphy was made. The three dots, though faint, were not uncertain, since they were received during the time for which Marconi, before leaving England, had arranged with his engineer at the transmitting station at Poldhu, on the British coast. Here had been erected the powerful apparatus necessary for the generation of the electric impulses that started on their far, and seemingly blind, journey across the ocean from antennæ supported at the tops of tall poles. Meanwhile, Marconi had sailed for America, and, upon his arrival there, found to his disappointment, that much of the apparatus had been destroyed by a storm. Undismayed, however, on reaching St. John, Newfoundland, he succeeded in raising the antennæ to a considerable distance above the surface of the earth by means of kites.

At last, on that memorable twelfth day of December, 1901, at 6:30 P. M., the receiving instrument, in this case one of Alexander Graham's well-known telephones, gave distinctly the three successive ticks, followed by the intervals required by the Morse code to indicate the letter "S." The inventor listened, almost unwilling at first to credit the glorious evidence of success that had followed so many failures. At length the signals were repeated in such a manner as to announce, unmistakably, the success of the experiment. The problem was solved, the trans-Atlantic space was traversed, and the electro-magnetic waves were ready to obey the behest of man, and to transmit intelligence anywhere over the face of the deep.

The transmission of trans-Atlantic signals having thus been demonstrat-

ed, Marconi soon succeeded in sending actual messages. On December 21, 1902, one year and nine days after the date of his successful transmission of the three dots, he announced the transmission of three entire messages from Cape Breton, Canada, to England. Of these, one was from the Governor General of Canada to the King of England; one from the commander of the Italian vessel, the "Carlo Albert," to the King of Italy; and a third from a special correspondent of the London "Times" to his paper. On January 19, 1903, a telegram was sent by the Marconi system from the President of the United States to the King of England.

Since these early messages were sent, the practical applications of wireless or space telegraphy have increased considerably, not only by the employment of the Marconi system, but also by the use of many other systems of wireless telegraphy, such, for example, as those of Prof. R. A. Fessenden, the Braun-Siemens & Halske system, the De Forest system, the Slaby-Arco & Braun, German system; the Ducretet & Rochefort, French system, and many others.

So general have been these applications that, at the present time, there is practically no warship without wireless telegraphic apparatus, and the same is true of the better class of passenger steamships crossing the Atlantic, and other oceans and inland seas. Indeed, on some of the passenger steamers, miniature newspapers are published for the purpose of giving to the passengers the news of the principal events, which are constantly being received as wireless telegraphic messages, from different parts of the world.

Successful wireless telegraphic communication is steadily increasing. It was only recently,—on December 27, 1905,—that the newspapers contained an account of a wireless message having been sent from Guantanamo, Cuba, to Boston, Mass., a distance of 1700 miles, the despatch being a reply to Admiral Dewey's wireless Christmas greeting from Washington to Cuba.

It is seldom that any individual is so far in advance of his fellows as to be able to plan an absolutely novel achievement in the natural sciences. The great feat of Marconi in wireless telegraphy was by no means an exception to this general statement. Marconi's results represented but the final step taken in a long series of investigations made by many able pioneers who preceded him. These investigators made the discoveries of the principles on which the invisible electro-magnetic rays can be set up, can be caused to traverse extended distances of wireless space, and can afterward be forced to reveal their presence by one or another of the many pieces of apparatus that have been successfully employed for this purpose.

Marconi himself thus acknowledged this in the address which he made at the memorable dinner given to him on January 13, 1902, by the American Institute of Electrical Engineers. "Time has not permitted me to make any reference to the history of wireless telegraphy. I wish you to know how much the success of my work has depended on the work of my predecessors and my present assistants. I have built very greatly on the work of others, and before concluding, I would like to mention only a few of the names. I may omit some, but these occur to me at present. They are Clerk Maxwell, Lord Kelvin, Professor Henry, and Professor Hertz."

Marconi afterwards mentioned the name of Alexander Graham Bell, on whose telephone, as a receiver, he had received the first trans-Atlantic message.

The fact that Marconi's work was thus based on the work of his predecessors should in no respect abate, by one jot, the distinguished rank that has been accorded it, since work of this character requires no ordinary ability to know what to take

from the work already done, and what to add in order to achieve success.

ROENTGEN RAYS AND RADIO-ACTIVITY

In December, 1895, a discovery made by Professor Roentgen, of Würzburg, Bavaria, of a peculiar form of radiation known as the X or Roentgen rays, led, some little time afterwards, to the discovery by Becquerel, by Professor and Madame Curie, and others, of the wonderful phenomena of radio-activity. While these discoveries strictly belong to the last decade, yet they were so greatly developed during the last half of this decade as to properly belong to the period now under consideration. These discoveries were due, for the greater part, to the investigations of many distinguished scientists, such as J. J. Thomson, Rutherford, Lodge, and others, thoroughly capable of following the indications of this attractive, yet difficult, subject. Their tireless investigations in radio-activity soon led to results that are so far-reaching they may justly be regarded as among the most important scientific achievements of this period. Lack of space will prevent other than a brief mention of some of the more important of these results.

THE OVERTHROW OF THE OLD ATOMIC THEORY OF MATTER

The atomic theory of matter has been held as a fundamental belief in chemistry almost without intermission from the time of its first enunciation by John Dalton, in 1807, to about the beginning of the twentieth century. This theory assumes that matter consists of almost infinitely small particles that are infinitely hard, and are, therefore, incapable of any change, being equally unaffected by intense heat, by attrition or compression, by electricity, chemical action, or any other known natural force. Although towards the close of the nineteenth century a belief began to be entertained by many scientific men, of the insufficiency of the atomic theory, yet it was not until the phenomena of radio-activity began to be more thoroughly examined that the conclusion was reached that it was no longer possible to regard the so-called chemical atom as the ultimate particle of matter.

It is now generally recognized that the so-called chemical atoms, although themselves of extremely small dimensions, nevertheless consist of an aggregation of still smaller particles, or, in other words, that the so-called chemical atoms do not consist of single entities, but are composite in structure. That is to say, an atom is capable of having particles broken off from its mass. Since the presence of all its particles is necessary in order to impart to an atom its characteristic properties, it follows that the so-called chemical elements must be capable of being changed into other elements, and that the old dream of the alchemists, as to the possibility of transmuting the baser metals into gold, can no longer be regarded as an impossibility.

The investigations into the properties of radio-active substances soon led to the discovery of a number of new elements, the most remarkable of which are radium and actinum.

APPARENT CONTRADICTION OF THE DOCTRINE OF THE CONSERVATION OF ENERGY

It can be shown that the element radium, which possesses in a remarkable degree the properties of radio-activity, is capable of emitting energy at a rate far beyond the maximum energy that any known substance was thought capable of possessing. Many explanations were made in order to explain this phenomenon, among them, that the radium acquired an additional energy from some system outside its own mass, but the improbability of this explanation having been established, it seemed at first as though the doctrine of the conservation of energy would require to be modified. With-

out, however, going further into this matter, it may be said that it is now generally recognized that, owing to the much more highly complex nature of the atoms of matter, the amount of potential energy they naturally possess is greatly in excess of what has ordinarily hitherto been ascribed to them.

As regards the possibility of actually manufacturing the so-called elements of matter, it may be interesting to note that the genesis of the element helium has been detected in the changes that take place in the atoms of radium during the losses to which they are subjected by the emission of particles radiated from their masses. According to the now generally accepted theory that the radio-active elements owe their peculiar properties to the fact that they are constantly undergoing atomic disintegration, it necessarily follows that as they lose certain portions of their mass they must thereby acquire different properties, that is, pass into other elementary forms.

This change, however, is so slow in the case of uranium or thorium, that at least a million years would be required before the amount of the change would produce a difference in weight capable of being detected by a delicate chemical balance. In radium, where the disintegration is fully a million times more rapid, the rapidity of the change is proportionately greater; yet it may be regarded as doubtful whether, even here, any appreciable change could be expecten that would be capable of detection by ordinary chemical methods until after a lapse of many years.

AN ELECTRICAL THEORY OF MATTER

Probably one of the most interesting results that have followed the careful study of the phenomena of radio-activity has been the formulation of what may be called the electrical theory of matter. It has very frequently been stated, as a reproach to modern physicists, that with all the vaunted advance in electrical science, there exists an actual ignorance concerning the real nature of electricity. While this may still, to a great extent, be regarded as true, yet it now seems very probable that ordinary matter consists in reality of a combination of positive and negative electricities, and that the phenomena of electrification consist practically in the separation of the positive and negative varieties of matter.

THERAPEUTIC USE OF RADIUM

Closely connected with the discovery of radium and its properties is the electro-therapeutic use of radium for the treatment of certain diseases, such as cancer of the œsophagus. The use of radium for this purpose has been markedly successful, but is unfortunately limited by the small quantity of the material that is at the service of the electro-therapeutists. In the treatment of cancer by radium, a bougie, covered with a radium salt, is introduced into the part to be treated, and permitted to remain for several hours. Treatment of this character requires considerable care, since painful burns may be produced by too prolonged exposure to the radium rays, but when properly administered it has produced very satisfactory results.

It is the opinion of many competent physicians, an opinion based on actual trials, that beneficial results would accrue in the case of such diseases as cancer of the stomach by the careful administration of small quantities of radium salts in solution, that is, having these salts actually introduced into the stomach of the patient by swallowing. At the present time, however, the high cost of radium salts, and the limited quantity of the material that has been isolated, effectually prevent further researches in this direction. That much good may result, however, from the continuation of these researches, would appear very probable.

In a somewhat similar manner, the

application of the Finsen rays to the human body has met with marked success during the past half decade. The Finsen treatment consists in a localized treatment of various diseases of the skin, including lupus or tuberculosis of the skin. The curative agent is a highly concentrated beam of the ultra-violet light obtained from powerful carbon arc lamps, the light being concentrated by passage through suitably shaped lenses. In order to prevent burning by the heat rays, the rays are filtered by passage through substances that are transparent to the light, but which will absorb or prevent the passage of heat.

As regards the success of the Finsen treatment for lupus, it is interesting to note, from the actual statistics of an institution especially established at Copenhagen, Denmark, in 1896, for the treatment of this disease, that out of a treatment of over six hundred cases, there were only from 1 to 2 per cent. of failures, and that these failures consisted largely of cases that had been permitted to reach such a diseased state as not to be amenable to treatment. It is difficult to form an estimate of the great boon to suffering humanity that has resulted from the success of the Finsen treatment. Since the establishment of the Copenhagen institution in 1896, Finsen has introduced a number of marked improvements in his apparatus, as well as in the methods of treatment.

It may be generally remarked that progress in electro-therapeutics during the last half decade, has gone on not only along the lines of greatly improved forms of apparatus, but especially along the lines of the more intelligent use of such apparatus, electro-therapeutists of the past few years being much more thoroughly equipped with such necessary knowledge of the human body and its diseased conditions as to permit them intelligently to apply the powerful force of electricity as a therapeutic agent.

ELECTROCHEMISTRY AND THE ELECTRIC FURNACE

The progress in electrochemistry during the last half decade has been especially marked. The reason for this advance is undoubtedly to be found in the cheap electric power afforded by the installation of large generating stations, such as at Niagara Falls. Under these conditions many processes have been made practical that otherwise would have been impossible on account of the cost for obtaining the electric current.

The practical work of the electric furnace has been based on a magnificent series of experiments undertaken by Henri Moissan, a member of the Institute of France. These experiments, extending from the latter part of 1892 up to about the present time, were made either by Moissan himself, or by his pupils. Moissan devised a number of different forms of electric arc furnaces, by means of which temperatures can readily be obtained as high as 4000 degrees C. (7232 degrees F.). At these high temperatures all known chemical substances are liquefied and volatilized. By their aid Moissan, and others, have succeeded in forming many chemical compounds that were unknown before this time. A series of metallic carbides, silicides, and borides were formed, and improved methods were employed for the production of metallic chromium and manganese,—metals, that before the advent of the practical electric furnace, had been unknown except as curiosities in chemical museums, and that even then had never been obtained in the pure state.

During this series of electric furnace investigations, Moissan conducted a brilliant series of researches on the artificial production of the diamond. In this work Moissan carefully reviewed investigations that had been made prior to his time. He disproved the conclusion reached by the earlier investigators, that because certain furnace products possessed the necessary degree of hardness to

scratch and cut a ruby, or especially to scratch a diamond, such substances were necessarily to be regarded as artificial diamonds. Moissan showed that many of the products of electric furnaces consist of substances that are capable of scratching the ruby with ease, such, for example, as many of the metallic carbides, borides, nitrides, silicides, and carbo-silicides, while boride of carbon is capable of slowly cutting the diamond itself, and the carbo-silicide of titanium is almost as hard as a transparent diamond. He succeeded in forming, as a result of an extended and magnificent series of experiments, artificial diamonds, both of the opaque or black variety, and of the transparent variety.

It was during these investigations with electric furnaces that Moissan called attention to the exceedingly interesting fact that, in view of the ability possessed by the metallic carbides of being decomposed by contact with cold water, with the production not only of gaseous, but also liquid and solid hydrocarbons, it was conceivable that during the earlier geological periods of the earth, all the carbon on the earth existed in the form of metallic carbides, and that as soon as water began to play an important part in the chemical reactions that took place, the carbides were decomposed, yielding hydro-carbons that were finally transformed into carbonic acid gas by oxidation. In other words, he proposed an electrochemical theory for the production of petroleum and the paraffines, based on the decomposition of metallic carbides my water.

Applying these principles to the present volcanic phenomena of the earth's crust, Moissan suggests that since, as is well known, all the volcanic phenomena of the earth are practically limited to portions of the crust that lie either on the borders of the ocean, or in the neighbourhood of large bodies of water, these phenomena might readily be explained by the action of water on deposits of carbides in the earth's crust. While it is unnecessary to claim that all the volcanic phenomena of the earth can be traced to this cause, yet it must be acknowledged that the hypothesis would appear to possess great probability.

Since a measure of the success of any chemical or other process can be fairly determined by the amount of commercial product it produces, it will perhaps be well to discuss briefly some of the more important of the processes that have been installed at Niagara, New York, and take their electric power from the Niagara Falls Power Company.

The electric furnace product that leads all other electric furnace products, both as regards quantity and value, is calcium carbide. This material is employed for the production of acetylene gas, so largely used in artificial illumination.

The works of the Union Carbide Company are one of the largest located on the lands of the Niagara Falls Power Company. As is well known, the raw materials employed in the manufacture of this substance consist of burnt lime and finely ground coke, in the proportion of about three to two. These materials are first thoroughly mixed, and are then subjected to the prolonged action of the heat of the carbon arc.

A very high temperature is necessary for the production of calcium carbide,—a temperature that is considerably higher than that obtained in ordinary metallurgical operations. While either direct or alternating currents can be employed in the manufacture of this material, alternating currents are preferred, and in this particular case, are employed at a pressure of 2250 volts. Some idea of the extent of this industry can be had from the fact that the total current used by this company for the production of calcium carbide alone is equal to about 15,000 H. P.

The plant consists of about seventy-two furnaces, of which more than fifty are in constant operation. These

furnaces are circular in form, and are provided with a recessed rim, to the top of which segmental rings are bolted. Two carbon electrodes are placed at the top of a wheel in the space thus provided. The mixed charge of lime and carbon fed to them, is fused by the arc established between the two electrodes. The furnace is constructed so as to revolve slowly on trunnions, one complete turn requiring about 48 hours. The fluid carbide produced by the action of the arc is removed from the furnace; the ingots are taken comparatively cold from the lower side of the wheel, and form masses of from 24 to 30 inches in thickness. Each furnace has a diameter of about 10 feet, and requires a current of about 200 amperes at a pressure of 110 volts, or about 300 H. P., for operation. Each furnace has an output of about one ton per day.

The calcium carbide produced by this process is capable of yielding about 5 cubic feet of acetylene gas per pound of material. Acetylene gas, when properly employed, produces an agreeable, brilliant, and steady light, and is now used to a great extent for artificial illumination.

Another important electric furnace product produced at Niagara Falls is carborundum,—a carbide of silicon. This material is produced by subjecting a mixture of coke and sand to the heat of an electric furnace at a temperature of about 7000 degrees F. Carborundum is a very hard, brittle, infusible, and insoluble material. It ranks in hardness next to the diamond. Since it can be produced in large quantities at a comparatively small cost, it is now extensively employed as an abrasive material. At the same time, the ability of this substance to withstand high temperatures makes it very useful for furnace linings.

Carborundum is also used to increase the fluidity of molten metals, by an increase in their percentage of silicon. Owing to the high temperature at which carborundum is produced, this material can safely be added to a molten metal without danger of introducing impurities into the mass since, when properly made, carborundum contains nothing but pure carbon and silicon.

Another important electrochemical process extensively employed at Niagara Falls is for the artificial production of graphite. This product is manufactured by a process suitable for the conversion of the electrodes employed for electrolytic and electrometallurgical work into graphite. These substances are formed like the ordinary arc light carbons, by moulding under pressure a mixture of finely divided carbon together with some liquid readily carbonized. These materials, after being dried, are subjected to the action of intense heat, when the ingredients are bound together by the deposition in the mass of the carbon that has resulted from the decomposition of the liquid. The electrodes so produced are then subjected to a prolonged action of heat produced by bringing them to a state of electric incandescence.

Another process for the conversion of carbon in bulk into graphite consists in subjecting a mixture of finely divided coal, either pea or buckwheat anthracite coal, containing a small percentage of sulphide of iron, to the action of a high temperature for a period of about 20 hours. Generally speaking, artificial graphite possesses the advantage of being purer than most of the natural product, since the high temperature to which it has been exposed in its manufacture naturally results in driving off nearly all its impurities.

Still another electric furnace product is an abrasive substance known as alundum,—an electrically crystallized oxide of aluminium. This product possesses a hardness greater than that of corundum, and is now extensively employed as an abrasive. The raw material from which it is produced is known as bauxite,—an amorphous hydrate of aluminium.

Besides these products, there are a number of other electrochemical processes that are of equal importance, such, for example, as the electrical production of potassium chloride, of caustic soda, bleaching powder, the tetra-chloride of tin, the oxide of tin, tin crystals, the electrical production of sodium, of aluminium and aluminium alloys, the electrical production of lead, and the conversion of the lead so obtained into its compounds, such as litharge, red lead, white lead, etc.

ELECTRICAL FIXATION OF ATMOSPHERIC NITROGEN

Before dismissing the important subject of recent advances in electrochemistry, some reference should be made to a process of comparatively recent date,—the fixation of atmospheric nitrogen. A matter of great importance that has long attracted the attention of political economists is how best to maintain the wheat-producing capacity of land areas in such countries as Great Britain, where the acreage is necessarily limited. In view of the great demand that has been made on the natural nitrate beds of South America and other parts of the world, the necessity of ensuring the continuance of the supply of fertilizers has long been recognized. Now, however, by reason of an electric process by which it is possible to form directly from the elements of the atmosphere the necessary supply of nitrates, this matter is no longer a source of anxiety. Professor Crookes refers to this matter as follows:—

"The future can take care of itself. The artificial production of nitrate is clearly within view, and by its aid, the land devoted to wheat can be brought up to the 30 bushels per acre standard."

The process here referred to is briefly as follows:—The combination between the nitrogen and the oxygen of the atmosphere is ensured by the passage of a series of electric spark discharges, or minute arcs, through a current of moist air. The nitrifying chamber in which this combination occurs, consists of a vertical cylinder provided with a number of electric circuits so arranged as to maintain a number of minute electric arcs. A blower, operated by an electric motor, forces a current of moist air through the nitrifier. An absorption tower through which the air passes from the nitrifier, contains a solution of caustic soda which at once removes the nitric acid that is formed by permitting it to combine with the soda. The electric arcs are produced by a 10,000-volt dynamo. In a carefully conducted test made by Dr. Chandler, of Columbia University, New York City, it was shown that an expenditure of one kilowatt of energy per year would be capable of producing 1253.5 pounds of 70 per cent. nitric acid.

Another direction in which marked progress has been achieved during the past half decade is with the dirigible balloon. While it can hardly be said that a solution has been reached as to practical aerial navigation, yet much has been done in this direction. It will suffice here to state that on October 29, 1901, Santos-Dumont in his balloon succeeded in leaving a park in Paris, moving towards and circumnavigating the Eiffel Tower in that city, and then returning to the place of starting within less than half an hour, thus winning the prize of 100,000 francs that had been offered by M. Deutsch to anyone who could produce a balloon sufficiently under the direction of the aeronaut as to be able to move over a certain predetermined course within a reasonable time.

Dirigible balloons necessitate the employment of considerable energy in a small space. Both electric and petroleum motors have been employed as possessing this requisite. What the future may produce in this direction in the way of material improvement it is impossible to predict. Thus far, it does not appear that electricity has been very successful in aerial navi-

gation. At the present time the petroleum motor is more frequently employed for this purpose, the light petroleum motors of Daimler, and others, being employed. Some of these have a weight of only 10 pounds per horse-power. It is interesting in connection with this to note that Santos-Dumont's dirigible balloon employs the petroleum motor.

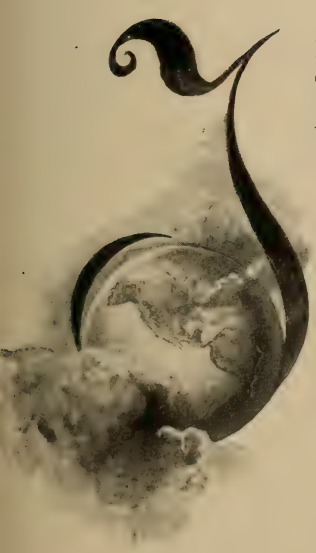
Thus briefly have been noticed some only of the many achievements that are to be credited to the last half decade. What great results are to be achieved during the next half decade is, of course, impossible to say.

Happy, however, should be those of the younger generation who possess the reasonable possibility of living in the near future, when so much will doubtless be accomplished toward the solving of many of the problems in physical science that today are regarded as almost unsolvable.

COAL TESTING

ITS IMPORTANCE IN INDUSTRIAL ECONOMY

By H. S. Knowlton



THE maximum utilization of the energy contained in a given quantity of fuel is a subject of never-ending importance in the industrial field.

In the constant effort to secure increased efficiency which characterizes twentieth century engineering, innumerable attempts have been made to secure greater economy of operation between the coal pocket and the switchboard, and many able minds are still focussed upon the fascinating problem of directly extracting for immediate use the potential energy of the fuel itself. Step by step the efficiency of prime movers has been increased and the combustion of the boiler furnace improved, until today we have boilers capable of utilizing at least 75 per cent. of the heat units in freshly mined coal, and gas engines guaranteed to produce 1 brake horse-power-hour with a consumption of 1.07 pounds of coal whose heating value is at least 13,500 B. T. U. per pound.

The maintenance of first-class economy at fractional loads is a familiar characteristic of the steam turbine and one of its greatest advantages, while the reciprocating engine itself has not been slow to enjoy the benefits of superheating.

In view of these points, it is somewhat strange that the importance of scientifically determining the quality and heating value of coal is in so many quarters either overlooked or treated with a degree of carelessness which is little better than absolute neglect. That accurate coal testing is a specialty in itself seems to be realized in few instances, although there are notable exceptions among some of the largest industrial plants.

There is a common belief at the present time that the operating experience gained in the boiler room is sufficient to demonstrate the quality and character of the fuel for all practical purposes. The idea is that

a daily or weekly report of the coal consumption in pounds per kilowatt-hour supplies an adequate check upon the general efficiency of the plant, and that any radical departure from the fuel specifications will immediately be manifested in the records of the power house attendants. A better illustration of the principle of locking the stable door after the horse is stolen could not be presented.

The combustion of coal is a chemical process; its behaviour during combustion, a physical phenomenon. Each must be considered in extracting the maximum heat units from a given weight of fuel, for either a variation of the chemical characteristics or an improper control of the furnace is capable of producing deceptive conclusions. The boiler room test throws light upon such troubles as insufficient or excessive draught, poor combustion, leakage of air, improper thickness of fire, grate area, and sizing of coal, and it is therefore of the utmost value in securing efficient operation, but it tells little or nothing about the intrinsic value of the coal itself.

To obtain accurate information in regard to the number of heat units which complete combustion of the fuel will yield, we must resort to chemical analysis or to the calorimeter test, either of which, if properly carried out, postulates the selection of suitable fuel for the work in hand, and, what is often of greater importance, determines the exact basis of payment between the consumer and the supply dealer. The practice of selecting fuel by simply inspecting samples of the kind of coal which the dealers agree to deliver is irrational to the last degree, for no man can obtain definite knowledge of the heating value of any coal by even the most critical physical examination. Nor is it possible to fairly decide, by such a method, between two coals of about the same quality, differing slightly in appearance. Nothing short of the laboratory test can solve the problem.

The saving sometimes effected in the final payments of consumers, based upon analyses and calorimeter tests, is very considerable. Take the case of a shipment of 10,000 tons of coal,—say, a year's supply,—costing $4 per ton on a contract basis of 14,000 B. T. U. per pound. If the laboratory tests show an average of 12,500 B. T. U., and the consumer pays simply for what he receives, the cost per ton is reduced to $3.57, which means a total saving of $4300. The cost of the determinations would be deducted from this at, say, $25 per analysis,—one a month,—leaving a net saving of nearly $4000.

In an industrial plant the selection of coal is almost as important proportionately as is the choice of raw material in a factory. The calorific power is frequently but one of several factors to be considered. Although the heating value of a unit of carbon or of hydrogen in all coals of the same nature is about the same, there is no doubt that in some cases the adaptability of the fuel to the particular furnace and service in hand is of sufficient importance to warrant the acceptance or rejection of a lot of fuel, quite apart from its relative heating power in comparison with its competitors.

A plant may be located in such close proximity to coal mines that the cost of other fuel is prohibitive; a coal may develop such tendencies to smoke that municipal regulations will debar its use; or a certain fuel may lend itself so well to the quick steaming required in handling peak loads, as in street railway practice, that other brands of higher thermal value per pound are not so desirable. These considerations in no sense depreciate the value of the laboratory tests, for in all cases the purchaser buys heat units, and should be advised to pay upon that basis in fairness to himself and to the dealer.

There is no better way to determine the relative ease of firing and

general adaptability of a fuel to a given plant than to actually give it a thorough trial in the boiler room, but sound conclusions can be reached only when the engineer and the chemist work toward the same end.

The demand of the consumer for coal of uniform quality is reasonable, but in the exigencies of practical mining it is difficult to perfectly sort out inferior grades and partings of slate, and in actual practice the fact that a coal bears a certain name is really of little significance as to its quality.

Within reasonable limits it is now possible to specify and obtain coal of practically uniform quality, but in any event the chemical analysis and the calorimeter test enable the purchaser to obtain his money's worth of heating power.

The accurate analysis of coal quality by either the chemical determination or calorimeter test is a problem for the specialist. Unless a company maintains an expert chemist and a well-appointed laboratory on its staff and in connection with its equipment, the writer believes that flue gas analyses, proximate or ultimate analyses of fuel, and calorimeter tests of heating power should be performed by a consulting chemical engineer, rather than by the home staff of mechanical or electrical experts. The cost of such determinations is a small matter in proportion to their commercial importance, and while the ordinary engineering force may be able, by careful work, to produce results of interest, there is not the slightest doubt that this is a case where the expert manipulation and experienced judgment of the specialist, coupled with the accurate equipment of the modern chemical laboratory, are certain to give far greater and more lasting satisfaction.

One of the most important phases of the coal testing problem is the impartial selection of samples. The personal equation must be eliminated in the effort to obtain a fair average of the barge load or pile. It is desirable that the consumer's engineer should be qualified to select such samples, in order to save the expense of calling in the specialist before his services are absolutely necessary.

Samples should be taken from a number of different places in the pile equidistant from one another, including large and small lumps, regardless of different quality. These samples should then be united and crushed, mixed, and subdivided until quartered selections of 20 or 25 pounds are obtained. These should be kept secure for analysis. The final samples for the chemist should be powdered coal capable of passing through an 80 to 100-mesh screen; these should be kept in tightly stoppered glass bottles. It is remarkable how little discrepancy will often be found between properly selected samples from the same barge load. But unless impartial sampling is carried out, the most painstaking work of the laboratory is of little avail in establishing correst conclusions.

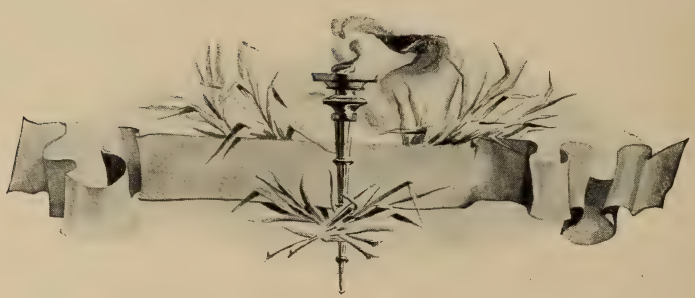
In discussing the influence of coal testing upon industrial economy, a few points may be noted in regard to the interpretation of chemical analyses. The literature of this subject is full of formulæ for the heating power in terms of the composition, and in many cases equations have been derived for the quality of coal found in particular localities. The ultimate analysis gives results which generally check far closer with calorimetric determinations than does the proximate analysis, and the latter should not be used alone when an accuracy better than 2 or 3 per cent. is desired. Ultimate analysis reduces the fuel to its elementary constituents of hydrogen, oxygen, nitrogen, sulphur, carbon, ash, and moisture. Proximate analysis determines the percentage of fixed carbon, volatile matter, moisture, and ash.

Probably the most satisfactory determination of the calorific power of fuel to-day is that effected by the

calorimeter, which actually burns a sample of fuel under known conditions, and measures with great accuracy the temperature rise of a surrounding water bath. Many engineers have contributed to the evolution of the calorimeter, but in far too many instances the results obtained have been more or less approximate. Possibly the defects of some of the earlier apparatus were in part accentuated by the misuse of the equipment in inexperienced hands; in other cases it has not been deemed necessary to eliminate various small errors, simply because they are small.

In the latest calorimetric apparatus, however, the utmost resources of modern science have been pressed into service to secure the desired precision of measurement. That such methods are available in the industrial field of to-day is cause for congratulation, and the results which are being obtained should go far toward establishing the true position of the laboratory in the conduct of modern industry.

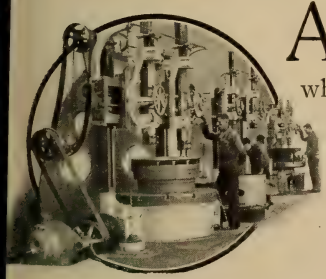
Throughout the engineering world production economy is to-day being studied upon the unit basis as perhaps never before, and although the determination of fractional qualities by refined methods often seems a needless waste of energy and money to the manager and executive dealing with production in bulk, the process of multiplying the conclusions of the laboratory by the total amounts of material concerned is sufficient to establish the economic importance of accurate work.



THE METRIC SYSTEM FALLACY

By W. M. McFarland

With the metric system fallacy once more in evidence through the antics of one of the daily newspapers, recurrence to it here may not be amiss; hence the abstract in the following pages of Mr. McFarland's testimony on the subject, given some time ago before the American Congressional Committee on Coinage, Weights and Measures. Mr. McFarland discussed the matter in a fair-minded, broad spirit with reference to its effect on the business of one of the largest manufacturing companies in the world.—The Editor.



AS soon as one has given some thought to what is involved in the change from existing English measures to those of the metric system, it becomes apparent that the change means great inconvenience and great expense, so that first of all it seems very fair that the question of the advantages of the change should be taken into consideration and discussed thoroughly, so as to see if they are so great as to materially outweigh the undoubted expense and annoyance of the change.

ADVANTAGES

Much to my surprise I find on discussing the subject with people who are as fair minded and free from prejudice as we are likely to meet, and who, moreover, are very progressive men, that none of them look on the change as particularly desirable.

C. C. Tyler, Works Manager of the National Cash Register Company, Dayton, Ohio, has had experience with the metric system at the Pratt & Whitney Company, where small arms and machine tools were built to metric measurements for certain classes of trade, and he is decidedly against the change.

A. M. Mattice, late chief engineer of the Allis-Chalmers Company, whose all-around experience and acquaintance with so many branches of engineering makes his opinion particularly valuable, sees no particular advantage to be derived from the change.

George M. Bond, late Manager of the Standards and Gauge Department of the Pratt & Whitney Company, of Hartford, Conn., who has given the subject great consideration and is an authority on accurate measurement, is very decidedly opposed to the adoption of the metric system.

W. R. Warner, of Messrs. Warner & Swasey, of Cleveland, Ohio, who have done a great deal of export work and who are noted for the high class work which they turn out, informs me that he is distinctly opposed to the adoption of the metric system for America.

This list might be multiplied, but it goes to show that whatever the advantages may be, such able men as those mentioned do not consider them sufficiently great to warrant the abandonment of our own existing system and the adoption of the metric one.

Some years ago Dr. Coleman Sellers, after the metric system had been in use in a portion of the Sellers Works in Philadelphia under his personal supervision, read a paper before the American Society of Mechanical Engineers distinctly opposing any thought of the adoption of the metric system by this country.

What then are the advantages solely set out for the metric system. They are:—

First.—The logical relation of the units of length, volume and weight, and the use of only one divisor in passing from one unit to another.

Second.—Greater facility of computation than in English measures.

Third.—The advantages to exporters whose products go to countries using the metric system.

LOGICAL RELATION OF THE UNITS

To the first heading there can be nothing but complete agreement. The metric system is thoroughly logical and the relations of the units are simplicity itself, but when we consider the question from the standpoint of the Westinghouse Company alone, and not from the broader one of all sorts of people and all lines of work, this condition does not have the weight which would seem at first sight to be very great.

In our work we are mainly concerned with the inch, its decimal multiples and sub-multiples, both for length, surface and volume, and the weights of material as calculated from them. Now, while the unit of weight has no logical relation to the linear unit, nevertheless, the determination of the weight of any given material from the cubic capacity is just as simple as in the metric system, as will be explained under the next heading.

FACILITY OF COMPUTATION

When we make a comparison between the simple metric weights and the complicated English ones of tons, hundred-weights and pounds, perhaps running down into ounces, the contrast is enormous, but as a matter of fact, we have simplified matters a great deal, and in our own electrical work the units we use are the inch, its decimal multiples and sub-multiples, and the pound with its decimal multiples and sub-multiples. As far as calculation is concerned, therefore, we are on an absolutely equal footing with the metric system.

It is too often forgotten, when referring to the logical relation between the units of weight and length, that while the unit of weight is the weight of a cubic decimeter of water, which would enable us to immediately get the weight of any volume of water by simply expressing it in cubic decimeters, in the vast majority of engineering calculations we do not deal with the weight of water at all, but with the weight of other substances whose specific gravity is represented by an irregular number. The result is that in the metric system the cubic contents has to be multiplied by this number to get the weight, which is exactly what is done when, in the English system, the cubic contents is expressed in cubic feet or cubic inches. The multipliers are just as simple in the latter case.

EXPORT BUSINESS

There will probably be entire agreement that it is much better to manufacture articles which are to go to metric countries to metric measurements, which is only one form of catering to the demands of the market which you wish to supply.

GENERAL REMARKS

When we look over the history of the adoption of the metric system both in France and later in Germany, we note that there was one immense argument in its favour which does not hold in considering its adoption in the United States or in Great Britain. There was no other system which had been worked out with care and in all its ramifications, to be displaced by the metric system. When the metric system was conceived it is a notorious fact that workmanship was so poor that the pistons of steam engines had to be made with soft packing because the cylinders could not be bored with sufficient accuracy to admit of the use of metallic packing, as at present. France itself was split up into different provinces with their own units of weight and meas-

ure. In 1871, after the formation of the German Empire, the constituent kingdoms and duchies had each their own system of weights and measures, none of which was logical nor had any particular recommendations. It was, therefore, a distinct advantage to get a system which was thoroughly logical, and well worked out in all its details.

In Great Britain and America today we find the system of weights and measures particularly has been most carefully worked out with excellent facilities for the obtaining of correct standards, together with ramifications in the shape of the manufacture of accurate scales and accurate measuring instruments.

Further than this we have a standard system of screw threads which has been most carefully worked out, and which would have to be abandoned if the metric system were adopted, and in America we have the only standard for pipe threads in the world. So far as I know, while there is an effort to reach an agreement on a standard metric system of threads for bolts and nuts, there is not yet any definite agreement, France having adopted for her Government service one standard which has not yet received universal approval, Germany having another and Switzerland still another, while none of these countries, so far as I can learn, has anything like a standard system for threads for pipes. None of them have even standard sizes of pipes.

DISADVANTAGES OF THE METRIC SYSTEM

At the very basis of a statement of the disadvantages of the adoption of the metric system, it must be carefully borne in mind that the relation of the meter to the inch is not exact, and not only so, but the ratio to get a fair approximation runs out to several places of decimals. This means that if we were to adopt the metric system it would not be the simple matter of expressing existing sizes in metric units rather than in inches, but that we should have to change all our dimensions enough to prevent the use of practically all of our present standards and require the adjustment to new ones.

The reason for this will be seen at once when we remember that an inch contains 25.4 millimeters. All experience shows that in practical work it has been found necessary to work to simple units, and their fractional sizes are used as simple fractions; thus the diameters of standard bolts vary by sixteenths in small sizes, eighths in larger sizes and quarters in still larger, and in the same way the number of threads to the inch are whole numbers. If we adopted the metric system we should, for example, have to substitute a twenty-five millimeter bolt for an inch bolt, and instead of taking eight threads to the inch or twenty-five millimeters, as at present, we should want a number of threads which would give a whole number of millimeters for the pitch. The same thing would hold as to the sizes of bar iron and steel and all the sheet metals.

It will be seen at once that this change to exact metric dimensions would involve a gradual change of all machine tools and of all drawings and patterns, to say nothing of the obvious abandonment of all the measuring instruments, such as scales, gauges, etc., graduated for English measures, and the substitution for them of others graduated in metric measurements.

A conservative estimate of the cost of the change in the shops of the Westinghouse Electric & Manufacturing Company is $300,000. This refers only to the tools, dies, jigs, etc., in the shop. If the change in drawings, etc., is included, the total cost would be more than half a million dollars.

The change would mean to the Westinghouse Electric & Manufacturing Company, and a similar statement would probably be true of most other manufacturing establishments, not merely the change in tools and

drawings to get the nearest sizes in even metric measurements to the existing ones, but it would even mean in many details the complete recalculation of many elements, because the existing machines are based on the use of standard sizes of wire, sheet metal, etc.

My attention has been called to a point in the cotton industry which is also worth considering in connection with this, namely, that an enormous amount of information has been collected or compiled of certain details of the business based on the inch, and the majority of this would have to be thrown away or translated into metric measurements with absolutely no gain to off-set the great expense and labour.

It must be realized that any concern which has been in the manufacturing business for some time is under a moral obligation to furnish its customers with repair parts. This means that for a long time to come, even if the metric system were adopted, such a company as ours would be compelled to maintain a considerable portion of the works for this repair work, together with all the measuring appliances, drawings, patterns, etc. In the case of a new establishment just starting business, this question does not, of course, arise.

There is also another point to be considered very carefully, namely, that manufacturing establishments are so related to one another that if the change to the metric system is to be made it must be made in all establishments at once. For example, those concerns which turn out bar iron and steel, bolt copper and brass, wire of various materials, etc., have, for years, been making their product of certain standard sizes. The manufacturers, to whom these are raw materials, have organized their work on the basis of these standard sizes, so that manifestly they could not shift to the metric system unless the makers of their raw material would also turn out new sizes to agree to the metric system.

CONCLUSION

On the whole, as far as the interests of the company I represent are concerned, I can see no advantage to be derived from the adoption of the metric system, while there would be an immense expense involved, and a disorganization of work, and an immense amount of additional work, lasting over a long period before things were gotten on the new basis.

In certain branches of manufacture, and in such matters as the drug business and matters of that sort, there seems to an outsider to be certain advantages, but considered solely from the standpoint of our own company there would be no advantage whatever in the adoption of the metric system, and from our standpoint we desire to be placed on record as opposing its adoption at present.

It seems to me as the result of my experience as a member of engineering societies who have handled questions analogous to this one, that the best way to get at what is most desirable would be to ask the various engineering and scientific societies in the country, whose membership includes all the manufacturers and scientific men, to appoint committees of their respective associations to form members of a great general committee who would consider this question on broad lines, and as affecting every interest in the country. The result of the deliberations of such a commission would be worthy of the very highest regard, and if such a commission recommended with reasonable unanimity as a whole, that it was desirable to adopt the metric system, the government could safely pass a law with such provisions as to time of adoption as the commission would recommend.

It is very worthy of notice in this connection that the standard screw thread, the standard pipe thread and numerous other standards which had been adopted by the engineering societies, have not had to be forced on

them by legislative measures, but have come about in a purely voluntary way because the needs for them were felt.

Prof. John E. Sweet, one of the past presidents of the American Society of Mechanical Engineers, before the same Congressional Committee, spoke as follows of the false claims of those who advocate the adoption of the lineal measure of the metric system in the Anglo-Saxon countries:—

"However ingenious the origin of the metric system so far as lineal measure is concerned, the standard is simply a bar of metal the same as in the English yard and possesses no merit over it, and it is no more likely to remain constant if both are kept at a constant temperature. The fact that there is a decimal definite relation between the lineal and the weight and capacity measures gives no commercial value because both of the latter are also referable to standards retained for reference.

"The fact that the divisions of each are in decimals possesses advantages in computations is evident, but this advantage is partly neutralized in the ordinary transactions of business because of the impossibility of overcoming the natural disposition of mankind to divide things in halves, quarters, etc., and more than overbalanced in practical use of ordinary lineal measures, as there are many conveniences incident to the inch, the foot, and the two-foot rule that no one has been able to produce, and never can produce and follow the decimal sub-divisions.

"The universal adoption of weights and capacity, were it possible and desirable, or in fact actually accomplished, would not render it any more necessary to adopt the meter for lineal measure than if they remain as now. The chemists can use the gram as a unit and it will have no more effect on our inch, foot or yard than does the decimal money system in America for example.

"It is true that the metric system has been adopted by the governments of about every civilized country except Great Britain, Russia and America, and it is claimed that it is used by more people than our English system.* This might be true if all the people of those countries used the system as universally as we do the English, and at the same time did as much weighing and measuring, neither of which is true. It is much less true in lineal measure than in weights, liquid, and dry measures. Much of the machine work in all of the metric-using countries is still done by the English measure and the amount of work done in a large majority of those countries is very insignificant.

"Mexico must be a fair example of such countries as Japan, China, and all of the Central and South American States. In Mexico the land measure and mining is done in the metric system; the railroads may have been built by the metric or English measure; the time-tables give the distance in both; the gauges of the roads are 4 feet 8½ inches; all the rolling stock is in English, and nothing but the English is used in the shops.

"I cannot conceive of the man who, after traveling from end to end of Mexico, would claim or believe that there is any more weighing and measuring done in the entire Republic of Mexico than there is in any second-class British or American manufacturing city, and lineal measure is much the least in proportion.

"The advocates of the measure believe that its complete adoption would improve foreign trade and fear without it we shall lose what we have. The facts so far do not justify this belief.

"No one questions but what we have enterprising machine tool, engine and agricultural machine builders. If the demand for machines in these lines built to metric measures had been of any apparent magnitude,

* The table on page 6 shows that this is not the case.—The Editor.

is it presumable that the most enterprising would have anticipated his competitors and supplied the demand. No evidence of any magnitude has been presented to show that this has been done, and if there is anything exported where this would have any bearing, it is in the machine line. And even had this demand for things to be made to the metric measure been a reality, what is there to prevent our manufacturers from meeting it without legislation, and why would the cost to them be any less by having the thing universal? The manufacturer must retain all his old patterns, special tools, jigs and drawings, the same in one case as the other because of repairs, and it is this question of repairs that makes the difference between the ideas of different mechanics.

"The bridge builder argues that the adoption of the metric system would involve no great outlay, and the change could be made in a few years. It would seem to me that the change would be made in almost no time, and of very little cost. A new set of drawings are to be made and they can be made at one scale as well as another, after the draftsman becomes a little used to it. The templates can be laid out pretty nearly as rapidly as by the English, but not quite, because the rule is not so convenient. A few punches and dies would have to be changed. The rolling mill would only have to make new rolls, and the rivet makers new dies.

"All this would take but a little time, and involve but comparatively little cost, but what would have been gained? A better bridge? No! One that can be built cheaper? No! Unless something can be saved in the mathematical calculations, and in this, with the slide-rule and tables, what percentage will it be when the whole cost of the bridge is taken into consideration? Possibly an estimable fraction. So far as the mathematical computations are concerned, it is likely there is as much done in the structural iron work in proportion to the cost of the product as in anything we have to deal with, but will the saving pay?

"While the advocates of the system, and we who do not believe either in its superiority or the desirability of its adoption, may reasonably differ, the advocates have never attempted to minimize the years and years of annoyance it would be to posterity were they to attempt to use and read our present literature wherever reference is made to our present measures. They see the apparent advantages it would be to some people to have a universal system, without any estimate of the comparatively few that would gain these benefits, and without heeding the many who would not only be inconvenienced, but put to an expense without any returns."

It may be interesting to refer here also to an article contributed to this

COUNTRIES USING THE FRENCH METRIC SYSTEM

	Population
1. Mauritius	371,655
2. Hayti	570,000
3. St. Domingo	610,000
4. Uruguay	*a* 728,447
5. Bolivia	1,192,162
6. Greece	2,187,208
7. Equador	1,271,861
8. Servia	2,226,741
9. Venezuela	2,323,527
10. Finland	2,380,140
11. Peru	2,621,844
12. Switzerland	2,933,334
13. Central America	3,053,000
14. Bulgaria	3,305,458
15. Chili	3,317,264
16. Columbia	3,878,600
17. Argentine	4,257,000
18. Portugal	*b* 4,360,554
19. Holland	4,669,576
20. Portugese Dependencies	5,772,824
21. Roumania	5,800,000
22. Belgium	6,195,355
23. Italian Dependencies	6,258,800
24. Norway and Sweden	*c* 6,817,782
25. Spanish Dependencies	*d* 9,695,567
26. Mexico	11,642,720
27. Brazil	14,002,335
28. Spain	*e* 17,565,632
29. Italy	30,535,848
30. Java	32,000,000
31. France	38,343,192
32. Ottoman Empire	39,212,000
33. Japan	40,718,677
34. Austrian Territory	*f* 41,358,886
35. French Dependencies	43,741,544
36. Germany	49,428,470
Total	445,296,003

a None of the first four are equal to the population of Liverpool.

b Lancashire alone in England had more inhabitants than any of the first 18.

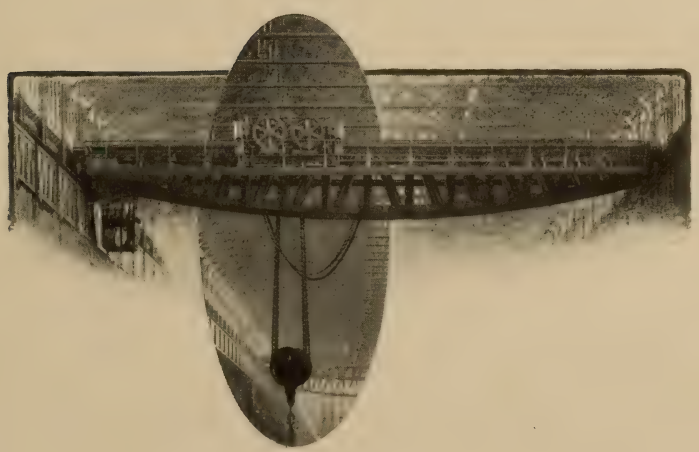
c The total population of the first 24 is about equal that of the United States of America.
d None of the first 25 equal the population within 50 miles of Manchester.
e The total population of the first 28 is equal to that of the Russian Empire.
f The British Empire alone has 4,000,000 more people than the whole of the first 34.

COUNTRIES NOT USING THE FRENCH METRIC SYSTEM

37. United States of America	76,000,000
38. Russian Empire	135,000,000
39. British Empire	356,000,000
Total	567,000,000

magazine for December, 1904, by George Moores, F. S. S., Secretary of the British Weights and Measures Association. Mr. Moores there stated that the argument that thirty-six nations have adopted the metric system, and only three, Russia, America, and the British Empire, have not, is often used by those who seek to make its use compulsory in the British Empire and America. But the metric advocates do not generally tell also that the population of the three countries exceeds by more than 120,000,000 inhabitants the population of the combined thirty-six other countries.

The tabulated figures on the opposite page are those given in evidence before the British Select Commission of 1895, in respect to the thirty-six countries, and those referring to the three are round figures from Blue Book returns of corresponding dates. In the British Empire, India is included, in which country though, by the Indian Acts No. XI. of 1870 and No. XXXI. of 1871, the French metric system was introduced, but never established for use in trade; the "Measure of Length" Act, 1899, adopted the English yard (not the meter) as the standard of length. China is not included in either set of figures. Its system is decimal, but not metric.



THE FUTURE OF TORPEDO CRAFT

By Archibald S. Hurd

AS a result of the war between Russia and Japan the naval authorities of the world are devoting increased attention to the design and construction of torpedo boats and destroyers, while sounds of the controversy as to the relative merits of the gun and the torpedo are still heard. There is a general agreement, however, among naval officers that the two weapons are complementary. They recognize that after a fight by day, torpedo craft may be employed by the victorious side with great effect to the annihilation of a foe who has already suffered during daylight serious damage through the action of the gun. In these circumstances, torpedo craft are eminently well fitted to complete the rout of an enemy.

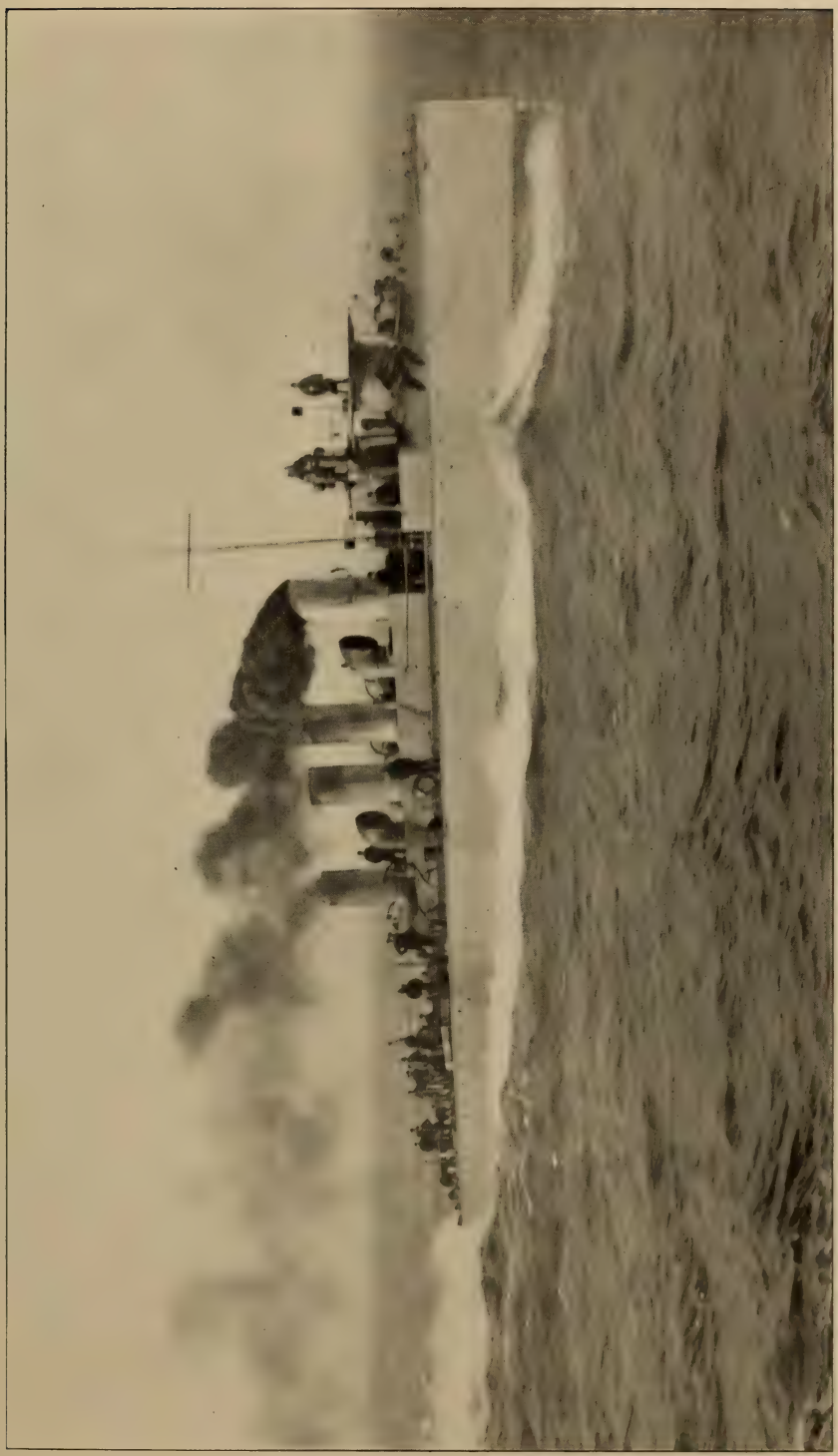
This combination of the gun and the torpedo was admirably illustrated by Admiral Togo's tactics during the battle of the Sea of Japan. At the same time, if Admiral Rodjestvensky had attempted to creep through the Straits of Tsushima during the night, it is admitted by the Japanese that Admiral Togo would probably have loosed his flotilla of torpedo craft upon the Russians while holding his battleships and cruisers in the background in reserve. He would have expected his torpedo craft to do considerable injury to the enemy, during darkness, besides undermining the morale of the crews. With the early streaks of dawn the torpedo craft, having confused and injured the enemy and delayed their progress, would have withdrawn, and the battle with the gun would have been opened.

Enthusiastic supporters of the submarine boat anticipate that the invisibility of this weapon might enable an admiral to employ the torpedo in narrow waters even during the hours of daylight; but at present all types of submarine boats are in the experimental stage, and reliance for torpedo operations has to be placed mainly in vessels navigating the surface of the water.

In all the navies of the world the operations in the Russian-Japanese war were carefully studied with a view to guidance in the future construction of torpedo craft, and it is already possible to indicate some of the chief results upon the construction policy.

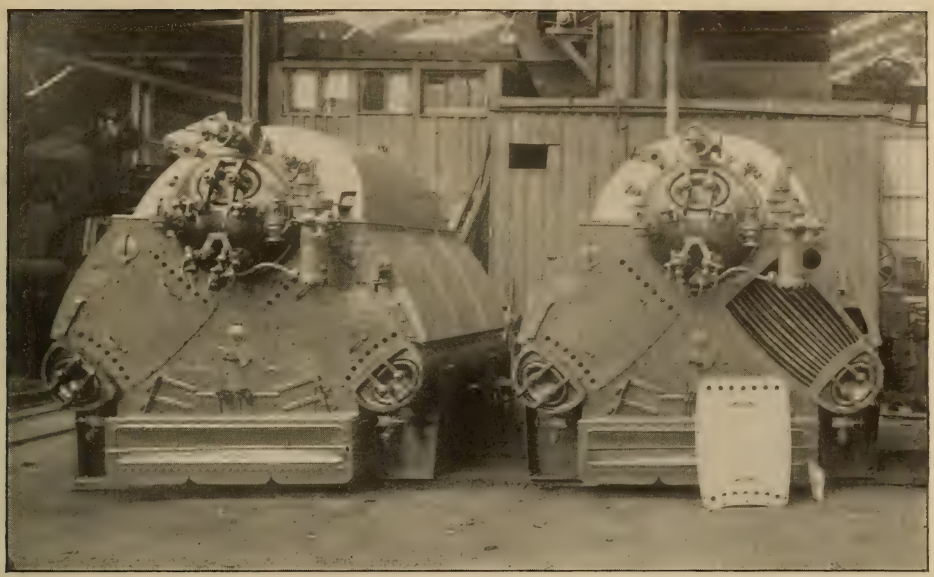
It is about fourteen years since the British Admiralty commenced to build torpedo-boat destroyers, and they stipulated for a maximum trial speed of from 26 to 27 knots. This type of vessel was intended to fulfill two roles. In the first place, it was claimed that it would be more effective for attack upon battleships and cruisers than the existing small torpedo-boats, as it possessed the great advantage of speed; in the second place, being provided with quick light-firing guns, it would be able, on occasion, to utilize its superior speed and sea-keeping qualities due to larger displacement in chasing the slower torpedo-boats, and, with the assistance of its gun, driving them off the seas or destroying them.

The builders had no difficulty in



THE JAPANESE DESTROYER "SAZANAMI," WHICH CAPTURED THE RUSSIAN DESTROYER "BIEDOVY," WITH ADMIRAL RODJESTVENSKY ON BOARD, AFTER THE FAMOUS BATTLE IN THE SEA OF JAPAN, MAY 27 AND 28, 1905. THE "SAZANAMI" WAS BUILT BY MESSRS. YARROW & CO., LTD., POPLAR, LONDON

THE TORPEDO BOAT DESTROYER "BAT" OF THE BRITISH NAVY, STEAMING AT 32¼ KNOTS. BUILT BY PALMERS SHIPBUILDING AND IRON COMPANY, LTD., JARROW-ON-TYNE

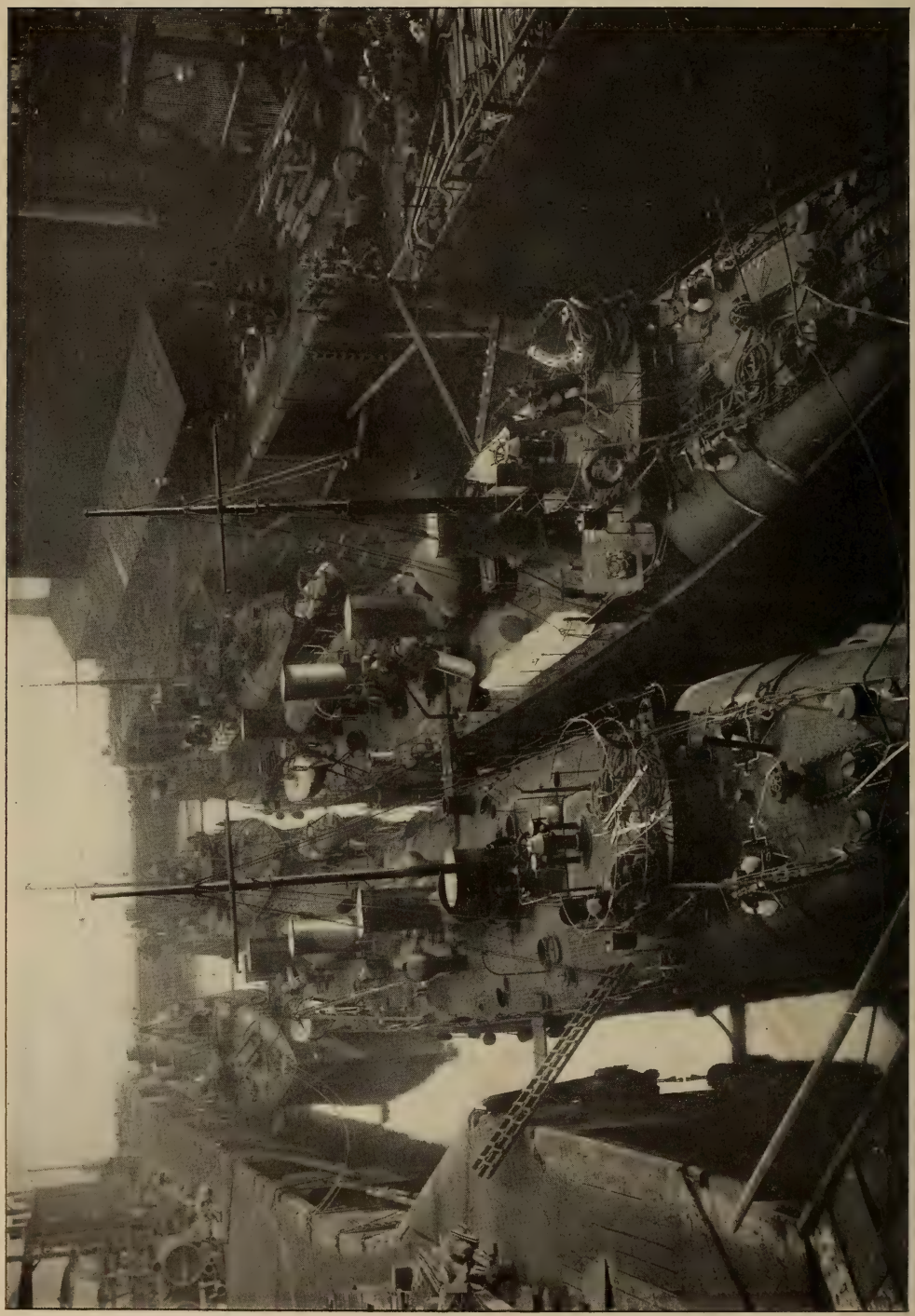


TORPEDO BOAT BOILERS,—500 H. P. EACH—BUILT BY MESSRS. J. SAMUEL WHITE & CO., LTD. EAST COWES, ISLE OF WIGHT

promising the Admiralty the speed required. This exceeded by a considerable margin the rates of steaming of the French sea-going torpedo-boats which had then been recently constructed in large numbers. The trial speed of 27 knots was obtained with little or no difficulty, and this success encouraged the Admiralty to demand even higher rates of steaming, with the result that gradually the standard was raised and the British fleet was provided with a large number of torpedo-boat destroyers of 30 knots trial speed. The 30-knot destroyers proved in every respect successful, even before the adoption of the water-tube boiler, but in order to obtain the increased speed the size of the boats had to be augmented. Some of the earlier 27-knot boats displaced as little as 240 tons of water and developed between 3000 and 4500 indicated horse-power.

With the demand for a greater speed the displacement of the boats rose rapidly to 300, and in some cases as much as 330 tons. Each builder was allowed a certain freedom in the design of the boats included in the contract, with the result that the torpedo flotillas of the British fleet have never been homogeneous. The main point was that the speed for which the Admiralty stipulated should be obtained under a light load, and so long as the vessels were constructed with what the Admiralty considered a fair margin of strength, the builders suffered from little interference in working out their designs, though the boats of each firm bore a certain likeness. Under the urgent demand for increased speed the indicated horse-power rose to 6000, and in some boats reached 6500. In a few vessels, even higher speeds, ranging up to 32 and 33 knots, were guaranteed, but those efforts were not entirely successful.

The "Express," the "Albatross," and several others of these swifter vessels gave considerable trouble during their trials, and for a long period failed to reach the maximum speed. The difficulties experienced with these craft seem to indicate that 30 knots was the maximum speed which could be obtained from vessels of 300 tons displacement; even this



FIVE 30-KNOT DESTROYERS IN DOCK AT THE BIRKENHEAD IRON WORKS OF MESSRS. CAMMELL, LAIRD & CO. LTD

rate of steaming was possible only in smooth water and with a light load, and in service conditions it fell off to the extent of 2 or 3 knots, so that the service speed amounted to a little over 27 knots.

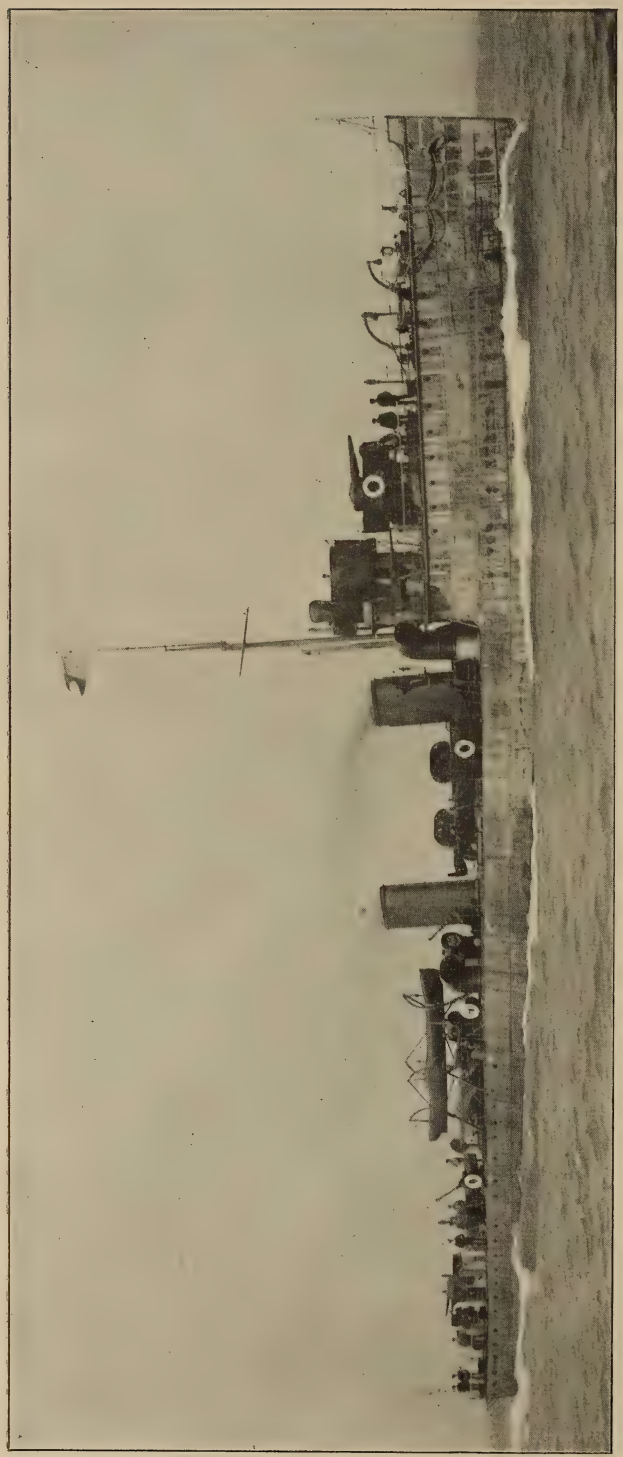
Some builders, however, believed that more work could be got out of such destroyers than had hitherto been obtained, and Messrs. Laird Brothers, of Birkenhead, England, made a very plucky effort to push the "Express" beyond the performances attained by any vessels at that date. Launched in 1897, this vessel was to have attained a speed of 33 knots. According to a Parliamentary paper, it made 27 preliminary and 10 official trials without giving satisfaction, although no less than 9000 indicated horse-power were obtained. About 30 knots appeared to be the maximum for vessels using reciprocating engines.

About this time, however, the Admiralty entrusted the Parsons Company with a contract to enable them to see what could be done with a vessel fitted with their turbine machinery. The little ship "Viper" was ordered in March, 1898, was completed in September, 1899, and on her trials proved a remarkable success. Under the Admiralty's contract conditions she attained the remarkable speed of 34 knots, with a maximum of 36½ knots. This ship proved a veritable 30-knot vessel in the open seaway under ordinary service conditions. Unfortunately, her career was cut short through misadventure,—she ran ashore off the Channel islands in a fog and became a total wreck.

As soon as these 30-knot destroyers were ready for service, they were commissioned and subjected to the severest possible tests. Experience showed that they were safe, reliable vessels of high speed when handled with skill in fair weather. They were constructed primarily for acting from a base as a reply to the menace of the large number of torpedo-boats which in time of war would infest the English Channel. Their capabilities for sea work proved so remarkably good, however, that the admirals of the squadrons, particularly in the Mediterranean Sea, acquired the habit of employing them as "sea gallopers," and even under the severe conditions of rough weather which were often experienced, the best of them did not reveal any signs of weakness. Many of them suffered from breakdowns, but there was reason to believe that these troubles were due more to the inexperience of the engineering staff, new to quick-running engines and water-tube boilers, than to any inherent defects of the ships. Naval officers expressed themselves highly gratified with the type of vessel which had been provided, and their confidence was so unbounded that these little vessels were kept at sea for long periods in the roughest weather.

While most of the boats gave excellent results, sea experience convinced the officers in charge that the new vessels were of uneven quality. The freedom which the Admiralty had given the contractors had led in some cases to the scantlings being too fine. So long as the boats were used merely in smooth water they proved successful, but many of them were unfitted for open sea work. In other cases the speed on trial was obtained by severely pressing the destroyers and by high-air pressure.

In passing, it may be noted that a striking feature of the eight destroyers built by Messrs. Yarrow & Co., Ltd., of Poplar, London, for the Japanese Government, was the low air pressure. This is a very important point, because as the boilers grow old they gradually become less efficient from sediment collecting on the inside of the heating surfaces, and soot and other non-conducting materials on the outside. Consequently, the only means of maintaining the efficiency of the machinery, especially of the boilers, is to provide boilers of very large size so that as their evaporative power diminishes in



THE LATEST BUILT DESTROYER.—OCTOBER, 1905,—FOR THE BRITISH NAVY, BY MESSRS. J. SAMUEL WHITE & CO., LTD.

course of time, a higher air pressure may be adopted, and the same quantity of steam generated as at first.

This is a matter of vital consequence, if it is hoped to maintain the efficiency of the vessels for lengthened periods. For example, Messrs. Yarrow & Co. put four boilers in the Japanese destroyers, but had they put in three they would probably have got a mile an hour more speed, as, when new, three would have given ample steam, and the saving in weight of the fourth boiler would have been a clear gain.

These considerations are rarely studied sufficiently, but the fact is that if there is only sufficient boiler power to get through the official trial and secure the speed stipulated, and there is no considerable margin in that power, the speed soon falls off. The Yarrow craft, for this reason and others, gave satisfaction throughout the war,—so much so, indeed, that Baron Yamamoto, the Minister of Marine, telegraph his appreciation of the firm's workmanship after the battle of the Sea of Japan.

The construction of a destroyer is one of the nicest opera-

tions which can be entrusted to a shipbuilder, and the building of a well-proportioned boat calls for the exercise of the greatest possible care in the apportioning of weights. No doubt some of the builders who entered into the speed contests initiated by the Admiralty had not the experience essential to the creation of this special craft, and the misfortunes which overtook some of the boats began to attract widespread attention at a moment when a great disaster focussed

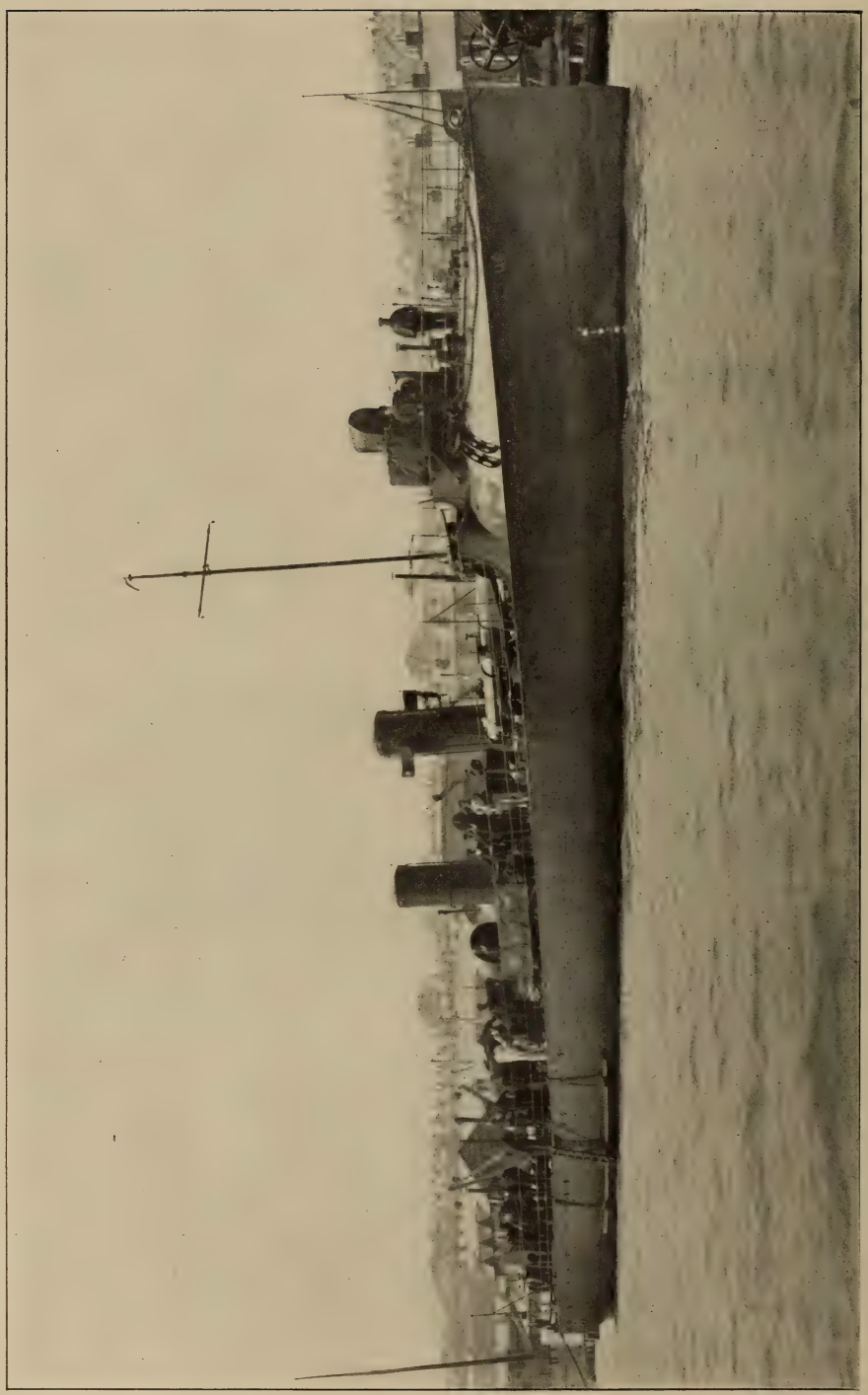
THE JAPANESE DESTROYER "SHIRAKUMO," BUILT BY MESSRS THORNYCROFT & CO., LTD., CHISWICK, LONDON

public attention upon the whole of the flotillas of the fleet.

Early in the year 1900 Sir William G. Armstrong, Whitworth & Co., Ltd., of Newcastle-on-Tyne, began the construction of the destroyer "Cobra" in conjunction with the Parsons Company. The vessel was built as a speculation for the special purpose of testing the Parsons turbine, free from the limitations imposed by the Admiralty. The vessel had progressed some way when the Admiralty decided to purchase her, and had her thoroughly surveyed. As a result of this examination considerably more material was worked into her structure in order to give longitudinal strength.

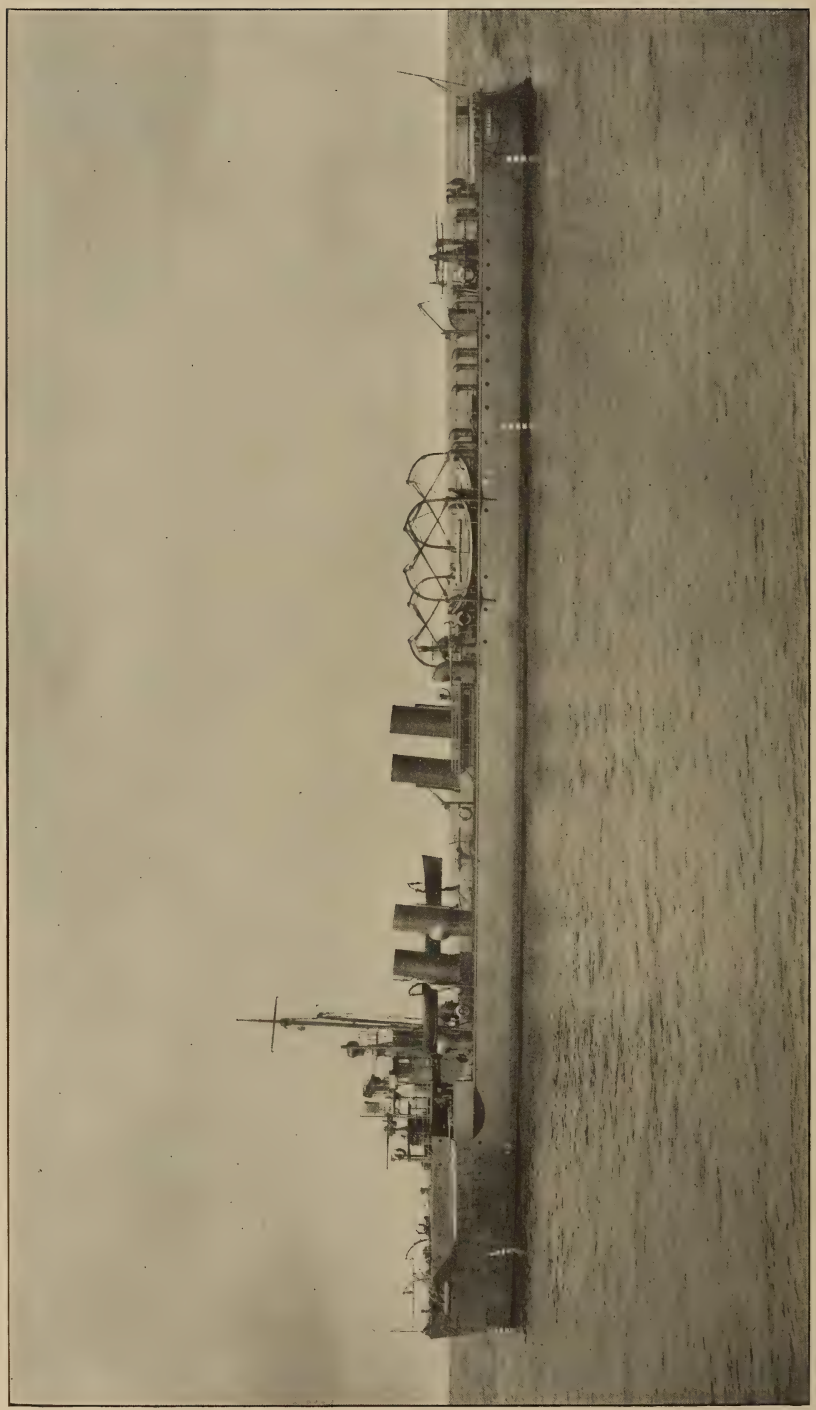
The "Cobra" was fitted with four shafts, with two propellers on each, making eight propellers in all, and on her preliminary trials she reached a speed of 36.4 knots. She had a length of 223 feet, with a beam of 20 feet 6 inches, but drew only about 7 feet of water. When the lightness of construction of such vessels is borne in mind, it will be realised that the beam and draught were altogether out of proportion to her immense length and must have brought a very severe strain upon her hull in consequence of the "hogging" and "sagging" movements which are felt with special severity in the North Sea. There is no doubt that the "Cobra" was not sufficiently strong to weather a rough sea, for on her voyage down the east coast she broke in two, causing heavy loss of life.

This disaster, coming on the top of reports of trouble with other destroyers of the British fleet, excited considerable attention, and an agita-



A FIRST-CLASS TORPEDO BOAT BUILT BY MESSRS. J. SAMUEL WHITE & CO. LTD., EAST COWES, ISLE OF WIGHT

THE BRITISH DESTROYER 'ALBATROSS,' BUILT BY MESSRS. THORNYCROFT & CO. LTD., CHISWICK, LONDON



ONE OF SIX DESTROYERS BUILT FOR THE BRITISH GOVERNMENT BY MESSRS. YARROW & CO., LTD., LONDON. LENGTH, 225 FEET; BEAM, 23 FEET 6 INCHES. GUARANTEED SPEED, 25 KNOTS WHEN FULLY LOADED, WHICH, DURING THE OFFICIAL TRIALS WAS EXCEEDED

tion developed in favour of the Admiralty abandoning the building of these craft. The fact which was apparently not fully realised was that no such accidents had overtaken other boats of that class, built more substantially.

British destroyers have been sent under their own steam to the Mediterranean and to China, and twelve destroyers constructed at Chiswick and Poplar have been safely navigated to Japan, making the voyages with complete success, although some of them met with more than usually heavy weather. These craft carried, in addition to their ordinary trial load, a number of extra bags of coal and a full complement of officers and men. The success of these craft, however, counted for nothing when the agitation caused by the "Cobra" disaster arose. In the public mind one idea usually holds sway to the exclusion of all others, and the facts that the "Cobra" had sunk in the North Sea and that the "Viper" had run ashore in the Channel islands obliterated all the evidence which had accumulated in support of the seaworthiness of even these fragile vessels when thoroughly well built.

It is now well understood by naval authorities who have had experience in torpedo craft that the designing and construction of these vessels are a special art which can be learnt only in the school of experience. The success of the firms who devoted themselves almost exclusively to this type of work, Palmers Shipbuilding & Iron Co., Ltd., for example, of Jarrow-on-Tyne; Messrs. Yarrow & Co., Ltd., and Messrs. Thornycroft & Co., Ltd., of Poplar and Chiswick; and Messrs. J. Samuel White & Co., Ltd., of East Cowes, has not been due to chance, but to the wide knowledge which they have acquired from year to year and the scientific skill which they have brought to bear upon all the problems which have presented themselves in the evolution of swift torpedo vessels.

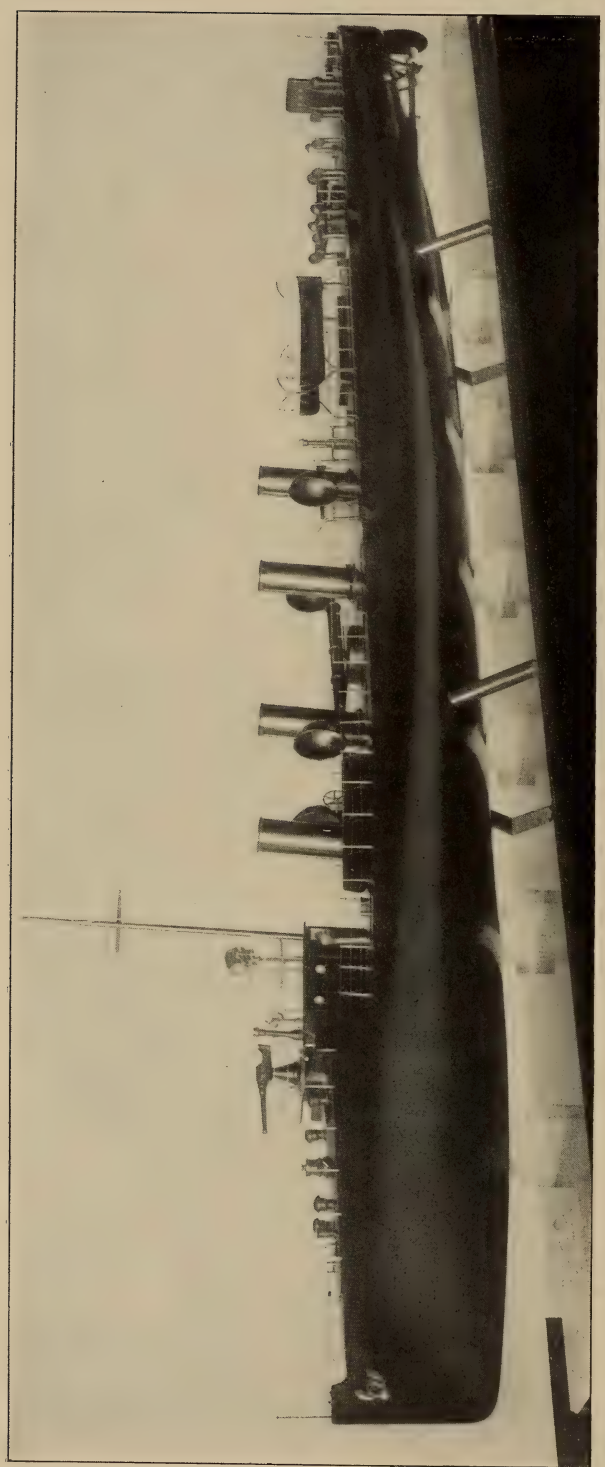
Under the pressure of public opinion, the Admiralty decided to construct no more 30-knot destroyers. In his memorandum accompanying the Naval Estimates for 1902, Lord Selborne announced "that designs and tenders had been invited for the ten new torpedo-boat destroyers in this year's programme. They will be of a modified type and a larger displacement, and of stronger construction and with improved accommodation for officers and crew as compared with existing vessels of the class.

These modifications will tend to improve the sea-going qualities of the vessels. The official trials will, however, be made at the top load draught,—a speed of 25½ knots under this condition being specified."

From the first, the decision of the Admiralty was viewed with skepticism in the Navy itself. It was contended that it was useless to build destroyers with a speed of only 25½ knots at a time when torpedo-boats were being built with a speed of 25 knots. To be effective, it was contended that destroyers should have an advantage of two or three knots at least, in order to enable them to overtake their contemporary torpedo-boats in an enemy's fleet; whereas in smooth waters the new destroyers, known as the "River" class, would have little or no advantage over the French or German torpedo-boats which were then being constructed.

From the first it was also realised that these new destroyers would be so big as to approach the size of small cruisers. They were given a displacement of 525 to 550 tons, and had to develop from 7000 to 7500 indicated horse-power. In armament they differed in no respect from the old 30-knot type, as they carried only one 12-pounder gun, five 6-pounders, and were given two torpedo tubes; but their coal capacity was greater, and at the same time the crew was increased to 70 or 72 officers and men.

In the programme of 1903 more



MODEL OF A PROPOSED 33-KNOT DESTROYER WITH TURBINE MACHINERY. A VESSEL OF THIS SPEED AND ON THE SAME GENERAL LINES IS NOW UNDER CONSTRUCTION BY MESSRS. J SAMUEL WHITE & CO., LTD.

of these destroyers were ordered, and in 1904 fourteen additional ones were to have been ordered, but were abandoned. As soon as the earlier vessels of this class had begun to pass into the fleet, upon completion, the Admiralty received reports condemning them as being too slow for the service they were intended to perform. It was admitted that in a heavy sea they maintained their speed better than the light destroyers of the 30-knot type, but it was pointed out that it was not certain that war would occur when the sea was in its most boisterous mood, and if it happened that these vessels had to be used when the water was calm they could not hope to overtake the light and cheap torpedo-boats of an enemy, and that they would, therefore, fail to fulfill their rôle as torpedo-boat destroyers.

The question was also raised as to whether these new destroyers, in view of their limited speed, were not too expensive. When the Admiralty first embarked upon the construction of destroyers, each vessel cost only from £35,000 to £40,000; when the 30-knot type was adopted the outlay rose to between £50,-

THE SWEDISH DESTROYER "MAGNE," BUILT BY MESSRS. THORNYCROFT & CO., LTD

000 and £60,000, owing to the increase in size and strength; and on vessels of the "River" class the expenditure was increased to about £75,000. In view of this fact it was contended that the destroyers were too expensive an investment, especially on account of the disadvantages which they embodied. In addition to the slowness of speed, the boats of the "River" class were still armed mainly with 6-pounder guns which, it was contended, were too light an armament, in view of the policy adopted in France of protecting the boilers and machinery with armour plates, and that the vessels formed too conspicuous objects at sea, owing to their great size and the prominence of the high forecastle with which they had been provided.

The controversy as to the best type of destroyer for the British fleet was still in progress when the war between Russia and Japan broke out. It was realized that the Japanese would be employing in this operation destroyers similar to the 30-knot type which had been condemned by British public opinion, and that, therefore, the experience of the Japanese would prove of supreme value for the guidance of the Admiralty.

The over-timorous critics of the swift British boats were amazed to learn that Admiral Togo had taken these frail vessels to sea with him for the attack on Port Arthur. It was the depth of winter when the war began, and the cold was extreme; but the Japanese, faced by a great national emergency, decided that they had no alternative but to employ their torpedo vessels to the best of their ability. The severity of the cold accounted in large measure for the failure of the Japanese to do greater damage with the torpedo in the early stages of the attack on Port Arthur, but they were not discouraged by their lack of success, and as month succeeded month, these destroyerss, working in relief to one another, continued to blockade Port Arthur.

The reports from the British attachés, who were privileged to watch the operations, say that these vessels proved in all respects able to cope with the roughest seas. The engineering staffs nursed them with consummate skill, it is true; but the fact was patent and admitted by the Japanese that the hulls of these destroyers, which had been built, for the most part on the Thames, by Messrs. Thornycroft and Yarrow, had proved admirable in all respects.

These facts could not fail to impress the British Admiralty, at that time busy in constructing the heavy vessels of the "River" class.

The Japanese experience was overwhelmingly in favour of the type of boat which the Admiralty, under the pressure of public opinion, had been led to abandon. The displacement of these vessels ranged only from 307 to 335 tons, with a length from 210 to about 220 feet, a beam of from 19½ to 20½ feet, and a draught ranging from 7½ to 9½ feet. Provided with reciprocating engines, these British-built destroyers had attained a speed of from 30 to 31 knots, attaining from 5800 to 7400 indicated horse-power.

While war was still in progress, the Admiralty determined to abandon the construction of the additional destroyers of the "River" class which had been included in their programme for 1904. They were apparently in considerable doubt as to the exact line to follow, because while the "River" class had been proved too slow for the general services of the fleet, and also too expensive for reproduction in any considerable quantity, the old 30-knot destroyers were too frail in construction, and did not, as a rule, maintain their speed satisfactorily under sea conditions. Eventually it was determined to lay down two types of destroyers,—one small in size, but of comparatively high speed and cheap, and the other of stiffer construction, larger size, and also of high speed, but costing more. It was considered that the former kind of destroyer, which could be built in large numbers, would be admirably adapted for the defence of naval and commercial ports, and they were forthwith christened "coastal" destroyers.

Contracts have now been placed for twelve of these vessels, which will have a displacement of just over 200 tons. These early vessels will be submitted to severe tests, and will have to carry a much heavier load at their trials than has been stipulated for in the past, as the hope of the Admiralty is to obtain a boat whose trial speed will approximate more closely to the speed under service conditions. These vessels will be required to steam at the rate of 30 knots an hour, and shipbuilders are showing no hesitation in promising this rate of steaming.

The larger type of vessel will be known as "ocean-going destroyers," and are intended to accompany the fleet for use not only in torpedo warfare, but as "sea gallopers," going anywhere and doing any errand requiring speed that an admiral may desire. Five of these ships are included in the programme, and their cost will be so heavy that the Admiralty will not repeat the design until they are satisfied that they have obtained an article well worth the expenditure. These vessels are to have a speed of 33 knots, and it is stipulated that this rate of steaming shall be obtained with a load of coal sufficient for a radius of 3000 miles at 10 knots. The boilers will be of the "Express" type, adapted for oil and coal, and the engines will be of the Parsons turbine design.

It is noteworthy that France and Germany are not making similar efforts to obtain high speeds. On the Continent of Europe a rate of steaming on trial of about 30 knots is all that is aimed at, but the British Admiralty are pushing forward with energy and courage, and while they are building these two new types of destroyers, they are also about to construct an experimental boat which is to have a speed of 36 knots. The success of this experimental craft is regarded by shipbuilders generally with some skepticism. It is realized that if it realizes expectations in the matter of speed and stability, the Admiralty will in future raise the general speed of their torpedo craft to this level.

The position of the naval authorities throughout the world with reference to mosquito ships can be

readily understood. Italy is building a battleship with a rate of steaming on trial equivalent to 22 knots an hour, and in several navies armoured cruisers are being constructed able to steam at 25 knots. In an ordinary sea these big ships lose very little of their speed, while torpedo craft are greatly retarded; consequently, it is realized that torpedo-boat destroyers must be pushed to a higher average speed if they are to prove of much use in naval warfare.

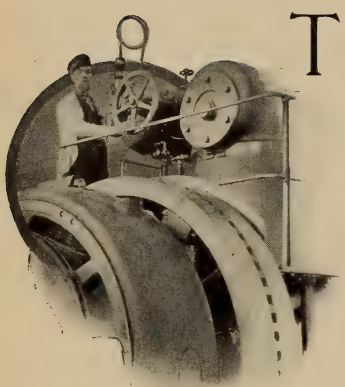
Speed is the prime consideration. Torpedo vessels must be sufficiently fast to enable them to overtake a fleet of big ships at night, and they must "have the legs" of armoured cruisers in order that they may escape if they are discovered under disadvantageous conditions. For instance, it is quite possible that during a war a number of armoured cruisers might come in sight of a flotilla of torpedo craft in the day time and be able to maintain a heavy fire upon them without giving them an opportunity of closing in to torpedo range. The speed of destroyers, consequently, is certain to increase.

Contrary to the opinion of many private shipbuilders, the Admiralty believe that they will obtain the type of destroyer they desire by utilizing the marine turbine. This conclusion is yet, however, to be completely supported by experiment, and in the meantime, on the Continent of Europe, as in America, the naval authorities are proceeding in this matter with extreme caution.

THE FAMOUS TURBINE-DRIVEN "VIPER," RUNNING AT 37 KNOTS

PRODUCER GAS FOR ELECTRIC POWER STATIONS

By Samuel S. Wyer



THE prime-mover equipment in the future development of power station work will not be exclusively along any one line, but rather will be based on the efficient development and use of different types of prime movers adapted to particular requirements and conditions; that is, the selection of the type of prime mover will depend on a careful and unbiased study of all the conditions and factors that will affect the proposed power plant. In such a preliminary study, a water-power plant will not be selected simply because nature has furnished a water fall; a stronger reason will be required for the selection of a steam plant than that of the large number in use; the uncertainty of natural gas will not be risked merely because it may be cheap, while the advantages of producer gas will be given a fair hearing. In short, the selection will be based on actual adaptability and not on superficial advantages or mere precedent. Since the power plant is the heart of any electrical distribution or transmission system, it is evident that the use of efficient prime movers is of the utmost importance in order to secure economic operation.

The high thermal efficiency of the gas engine is recognized by all engineers. For accurate and sympathetic regulation and general reliability, the gas engine is the peer of the steam engine. However, a suitable and low priced fuel is necessary. The main difficulty in installing a gas engine is generally that of a low priced and dependable fuel supply. The price of gasoline makes its use permissible only in small size engines. Natural gas, while an ideal fuel, is commercially available in only a few favoured districts. Even there, the uncertainty of the continuity of the supply involves considerable risk in installing engines for its use. The high cost of water-gas and its high percentage of hydrogen prohibit its use. The only fuel that presents a general practical solution of the problem is producer gas.

The object of the article here is to show the specific advantages of producer gas for electric power stations, and to discuss the factors that should influence its future introduction for such work, and the relation it sustains to the other sources of power.

The available sources of power for electrical power stations may be divided into four classes,—natural gas, water power, steam, and producer gas. While water power is generally the cheapest, yet its actual value has been much overestimated. The disforestation of large tracts of land whose drainage goes over a water fall, may make that source of power so irregular as to be useless. The use, or rather the ruination, of water falls having an esthetic value, as Niagara, for instance, does not meet with public approval, and public sentiment against such commercial vandalism will soon be crystallized into prohibitory laws.

Since the field of electric power consumption is rarely near the place

of power generation, the efficient electrical connection of the two involves the use of high-tension, long-distance transmission. The operation of this system will always be attended with short-circuit troubles from (1) climatic changes; (2) animals and innocent persons; (3) the ultra socialist who has a standing grudge against all corporations; and (4) the small boy who does not mean to cause any trouble, but yet cannot resist the temptation to have a pyrotechnic display of his own by getting some metallic object over two conductors.

In view of the territorial cost and continuity limitations of natural gas, and the natural, engineering, and probable legal limitations of water-power stations, it is evident that the future contest for general supremacy in this work lies between steam and producer gas.

The fuel bill of an electric power plant is always a large item. Even with large-size units there are few steam plants that can show a fuel consumption of only 2 pounds of coal per B. H. P.-hour; a large majority of the small plants use much more. However, with producer gas plants an economy of 1 pound of coal per B. H. P.-hour with small-size plants is common practice. In gas producer plants that utilize some of the sensible heat of the gas for preheating the fuel, and preheat the air, and superheat the steam used in the producer by means of the heat in the engine exhaust, a still higher economy may be obtained. In this respect, one of the greatest advantages of producer gas is its ability to give practically the same degree of thermal efficiency in a small plant as in a large one. In other words, with producer gas the small electric lighting plant of the village may be operated almost as efficiently, with regard to fuel cost, as the large plant of the city.

The higher fuel economy will mean a decided decrease in the cost of handling the fuel; the coal-handling machinery and coal-storage area may be of smaller capacity, and a corresponding decrease will be made in the cost of handling the ashes.

The engineering factors that should determine the location of an electric power station are:—(1) proximity to fuel and water supply; (2) Possibility of the plant being a nuisance to the neighbourhood; (3) Adaptability of ground for foundations; (4) The center of electrical distribution. The value of each of these factors must be co-ordinated to the plant as a whole. Since the amount of fuel used in a producer gas plant will be less than half, and the amount of water used will be less than one-eighth of the amount required in a steam plant, the effect of these factors in determining the best location will be decreased by a corresponding ratio. The foundation requirements will be the same for either a steam or producer gas plant. As the atmosphere will not be polluted either with smoke or dirt from a producer gas plant, and since the danger of boiler explosion is eliminated entirely, the nuisance factor becomes nil. As a result, more attention may be given to securing an efficient and centrally located plant.

In the future, in designing electric power stations, more attention will be given to the esthetic appearance of the building. This will be especially true of municipal plants. The elimination of the smokestack with its usual eye-sore effect and omnipresent smoke will make it possible to secure an architectural proportion, a pleasing harmony, and a permanence of colours unattainable with a steam plant.

There is no class of power generation where the continuity of operation and ability to take care of peak loads are of such vital importance as in the electric plant. This is of special importance where the plant supplies current for street railway operation. By means of a holder, it is possible to store a quantity of gas and have it ready for instant use in

case of accident to any gas producer or to meet an unexpected overload. The gas in the holder may be stored indefinitely without losing any of its thermal energy. Such a thermal storage arrangement is entirely out of the question with a steam plant. There are many steam plants where a minor accident, such as the bursting of a water-tube, has caused a shut-down for several hours, tying up street car traffic or leaving an entire town in darkness. The ability of the producer gas plant to store thermal energy is also advantageous in taking care of the regular peak loads.

The distributing pipes in a producer gas plant will give less trouble from leakage, contraction, and expansion, and they will radiate very much less heat than distributing pipes in a steam plant on account of the lower pressures and temperatures that are used. The lower temperatures of producer gas will be the means also of keeping the engine room cooler in hot weather than is possible with a steam plant.

For large electric power plants, the use of by-product gas producers may, under certain conditions, be advantageous,—i. e., a gas producer which, in addition to furnishing gas for the engines, furnishes an auxiliary product based on certain constituents in the raw fuel which would otherwise be wasted. The nitrogen in bituminous slack, by certain mechanical and chemical manipulations, may be converted into ammonium sulphate, which is a valuable fertilizer for certain soils. This by-product may be made to yield considerable revenue and, at the same time, permit the plant as a whole to have all the advantages already mentioned over steam plants. Such a by-product plant, to be successful, requires careful designing, judicious management, and a progressive sales department for the marketing of the ammonium sulphate.

The preceding paragraphs have shown how producer gas will be a factor in the future development of electric power stations. We will now show how, in certain cases, producer gas will compete with electric power stations. The competition may be divided into two classes:—Producer gas-engine-driven traction cars versus electric motor-driven traction cars, and central producer gas plants furnishing gas for scattered engines versus central electric power plants furnishing current for scattered motors.

Since gasoline-engine-driven traction cars are now in practical operation, it would be but a small matter to install a suction gas producer on each car and replace the gasoline with producer gas. With gasoline at 12 cents per gallon and coal at $5 per ton, a B. H. P.-hour will cost $1\frac{1}{2}$ cents with gasoline and $\frac{1}{4}$ cent with coal converted into producer gas. Hence, the cost of power per hour for a 100-H. P. car would be $1.50 for the former, and 25 cents for the latter,—an economy so obvious as not to require emphasis. The variation of the price of either gasoline or coal would obviously change the B. H. P.-hour cost by a similar ratio.

The use of producer gas-engine-driven traction cars would reduce the first cost of a traction line by eliminating the entire central power plant, trolley lines, feeders, poles, bonding of rails, and transformers. However, the cost of a producer gas engine and suction gas producer would be more than the cost of electric motors. No more labour is required to operate a producer gas engine-driven car than to operate an electric car. The feeding of the producer would be automatic, and enough coal and water could be placed on the car for an entire day's use. The line of demarkation between the fields where one would be more efficient than the other will depend upon local conditions.

There are many places where producer gas engine-driven cars would work more efficiently than electrically-driven cars. It is quite probable

that the "owl car" service of some cities would be included in this case. Many steam railways could place such cars on their standard lines without any change whatever to the roadbed or present power equipment, and would be able through them to compete with electric lines for suburban and interurban traffic.

The generation of producer gas in a large central plant and the distribution of the gas to scattered engines have been tried successfully, and under certain conditions such distribution is more satisfactory than electrical distribution.

CONTRACTORS' LOCOMOTIVES

Concluded from the January Number

By J. F. Gairns

IN the United States, so far as the writer's investigations show, there appears to be a strong similarity between four-wheeled engines built by different firms. The small engines are generally referred to as "dinkeys,"—a term presumably derived from workmen's slang, but now generally current even in advertisements and in general business.

Fig. 16 illustrates a very neat "dinkey" built by the American Locomotive Company, of New York. This engine may be regarded as typical of many thousand engines used in America and in colonial districts, though built by different firms. Except for the two large firms, Messrs. Burnham, Williams & Co. (Baldwin Locomotive Works, of Philadelphia, Pa.), and the American Locomotive Company, which is an amalgamation of about ten previously independent large firms, there are no builders in the United States who make main railway locomotives their principal product, but there are many firms which build these small engines as well as larger types of contractors' locomotives.

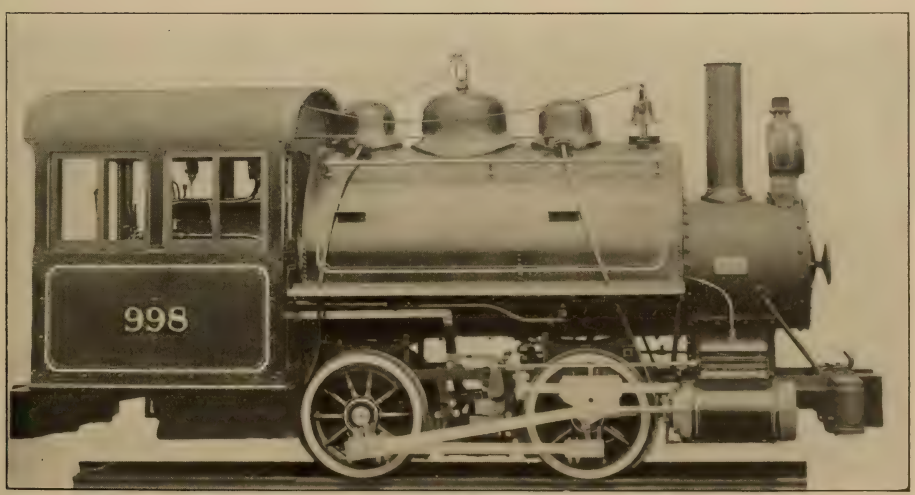


FIG. 16.—A "DINKEY" ENGINE BUILT BY THE AMERICAN LOCOMOTIVE CO., NEW YORK

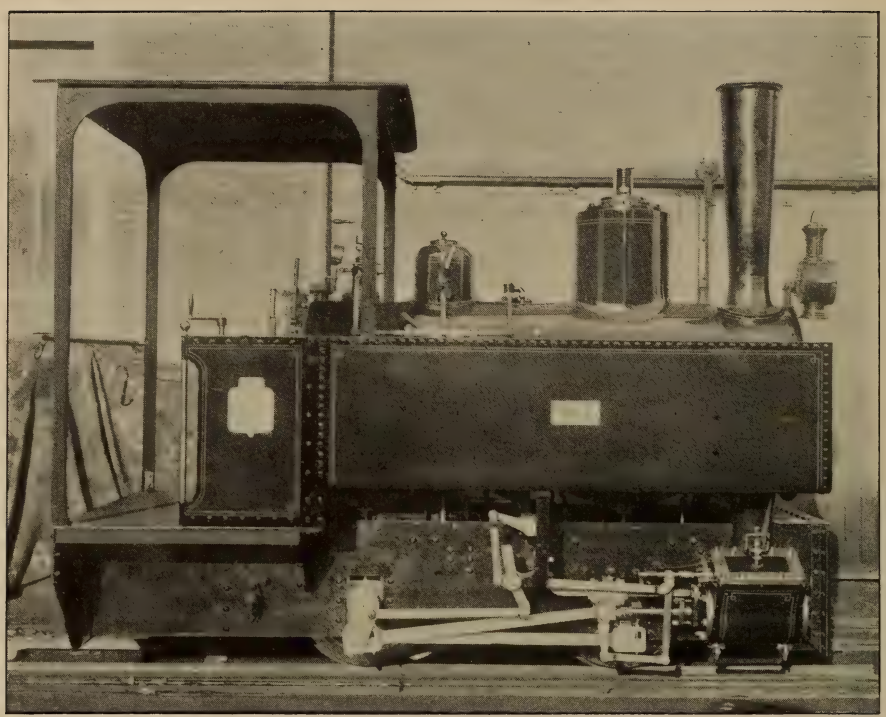


FIG 17.—A SMALL FOUR-WHEEL LOCOMOTIVE BUILT AT THE DECAUVILLE WORKS, PETIT-BOURG, FRANCE

FIG. 18.—TYPICAL FOUR-WHEEL SADDLE-TANK LOCOMOTIVE, BUILT BY THE BALDWIN LOCOMOTIVE WORKS PHILADELPHIA

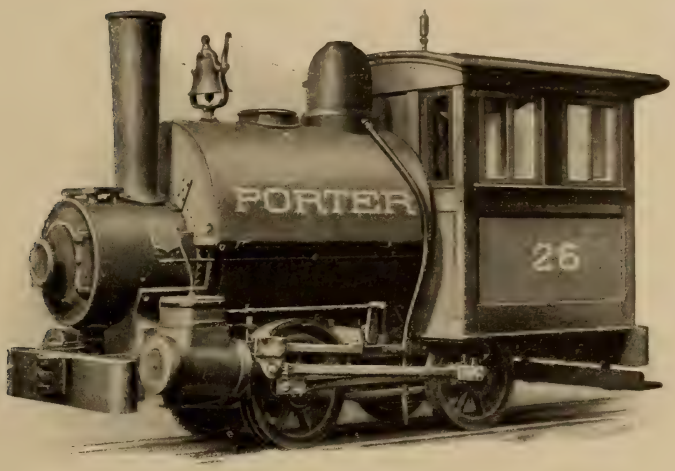


FIG. 19.—AN H. K. PORTER COMPANY ENGINE. A FAVOURITE TYPE OF AMERICAN ENGINE FOR USUAL CONTRACTING WORK

Fig. 18 is a representative four-wheeled, saddle-tank engine built at the Baldwin Locomotive Works for general contractors' use.

One of the principal American firms dealing with light railway and contractors' locomotives is the H. K. Porter Company, of Pittsburg, Pa., and Fig. 21 shows one of their extra heavy locomotives, with 10 x 16-inch cylinders, 36,000 pounds service weight, and 30-inch driving wheels. A number of these locomotives are in constant operation by the New York Contracting Company at their big contract for the Pennsylvania Railroad

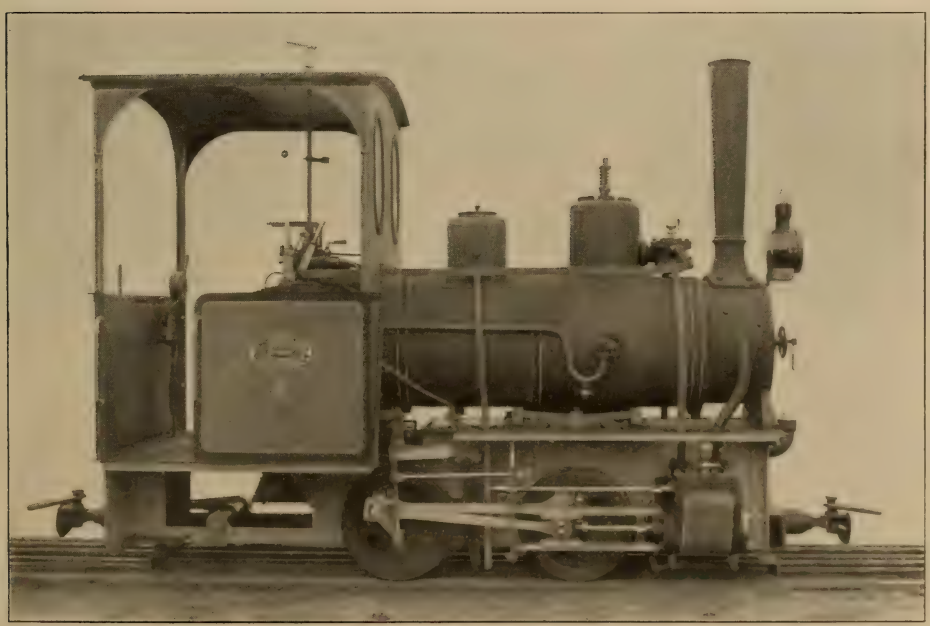


FIG. 20.—FOUR-WHEEL LOCOMOTIVE BUILT BY THE ARTHUR KOPPEL COMPANY, LONDON, BERLIN AND NEW YORK

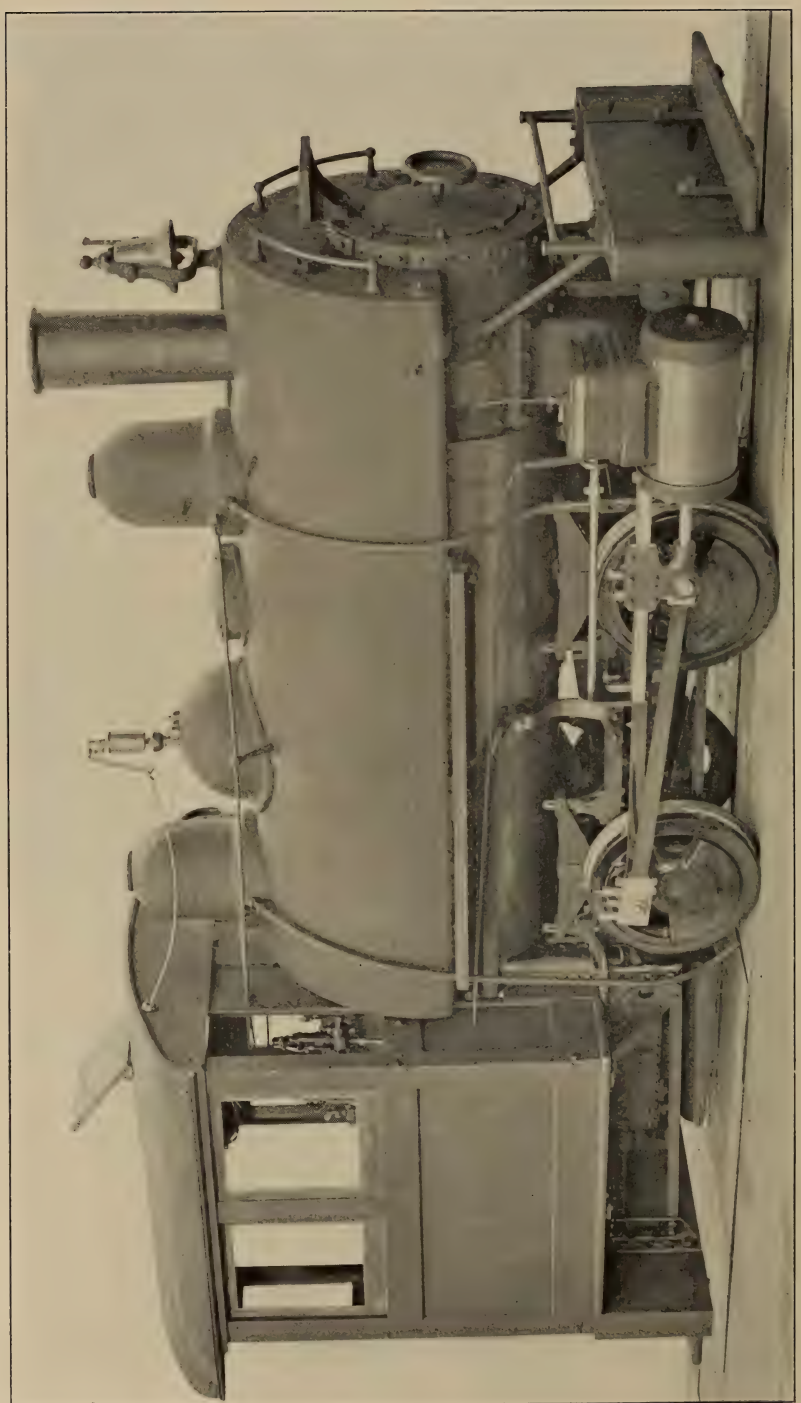


FIG. 21.—A SADDLE-TANK ENGINE BUILT BY THE H. K. PORTER COMPANY, PITTSBURG. AN EXTRA HEAVY LOCOMOTIVE FOR CONTRACTORS' USE

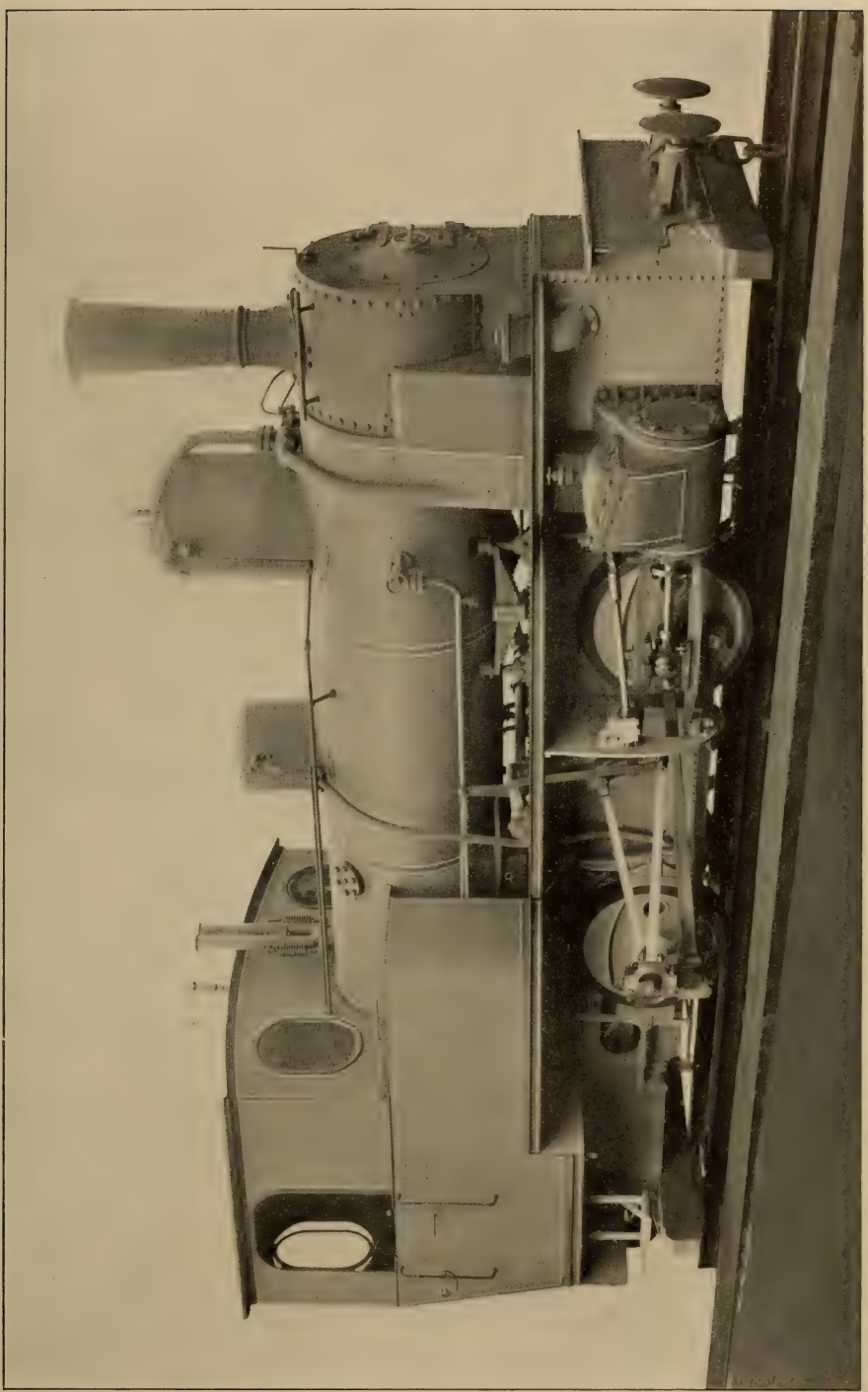


FIG. 22.—A LARGE FOUR-WHEEL ENGINE BUILT BY THE HANNOVER MACHINE WORKS COMPANY, HANNOVER, GERMANY

FIG. 23.—A GERMAN FOUR-WHEEL SIDE-TANK ENGINE, BUILT BY THE HOHENZOLLERN LOCOMOTIVE WORKS, DUSSELDORF

terminal, in the city of New York. Where the work is heavy, and powerful machines are needed, this is one of the best locomotives for contractors' use that has ever been brought out.

One special feature of this design for narrow gauge deserves mention. For as large a locomotive as this for 36-inch gauge it is impracticable to get an abundantly large free-steaming boiler on the ordinary plan of construction with continuous frames and a narrow firebox placed between the frames and behind the rear axle. This design, as the illustration shows, is therefore made with the main frames stopped off in front of the firebox, connecting to a heavy steel cross and tie-plate, to which the rear sections of the frame are attached. This gives a very strong, massive frame construction, just as desirable in all respects as the continuous

FIG. 24.—A LARGE SADDLE-TANK ENGINE BUILT BY MESSRS. ANDREW BARCLAY SONS & CO. LTD., KILMARNOCK SCOTLAND

FIG 25.—A SMALL SIX-WHEEL SADDLE-TANK ENGINE BUILT BY MESSRS. HUDSWELL, CLARKE & CO., LTD., LEEDS

frame construction, and admits of the use of a full-width firebox with straight sides. It gives a very large free-steaming boiler, and a perfectly balanced engine. The old way of building stopped-off frame engines is to attach the front sections of frame to the front part of the firebox, and bolt the rear sections of the frame to the sides of the firebox. This is open to the drawback that when the engine pulls from the back end of the engine, all the thrusts and pulling of handling trains is borne by the boiler, which is very objectionable. The construction here shown entirely avoids this difficulty.

The substantial character of these

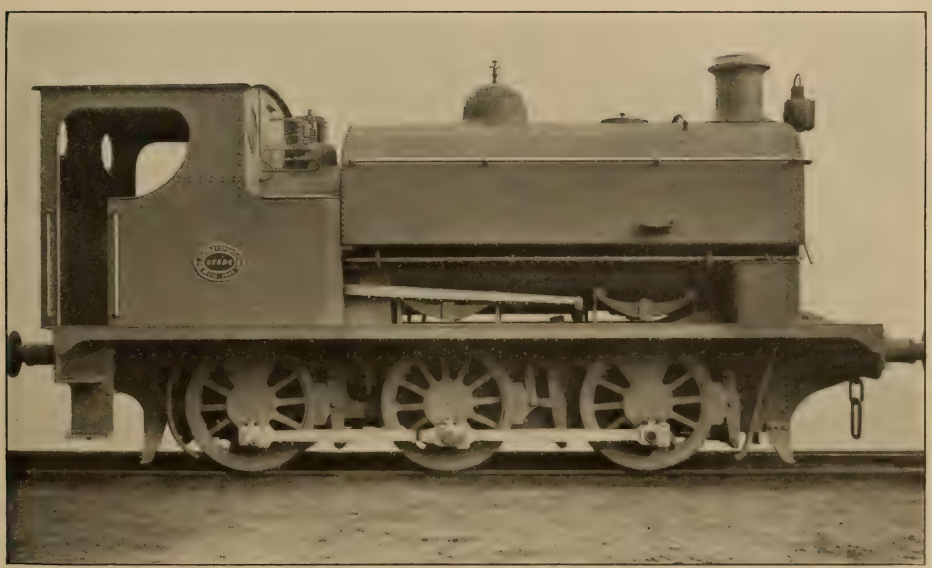


FIG. 26.—AN INSIDE CYLINDER SADDLE-TANK ENGINE BUILT BY THE HUNSLET ENGINE CO., LTD., LEEDS

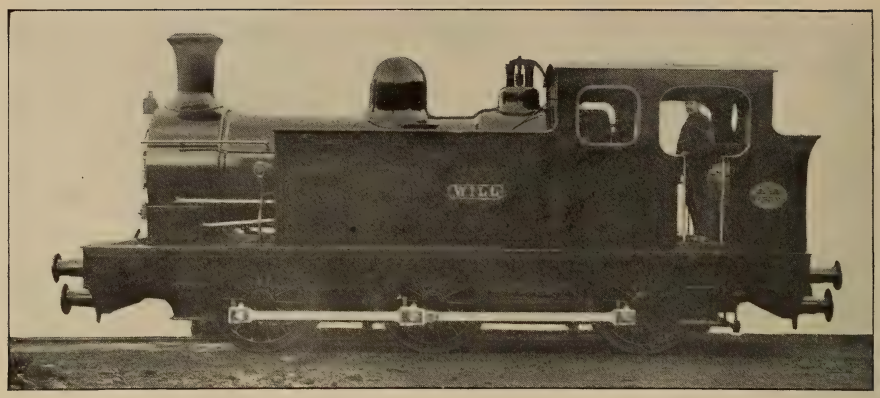


FIG. 27.—A SIDE-TANK ENGINE BUILT BY MESSRS. A. BARCLAY, SONS & CO., LTD., KILMARNOCK

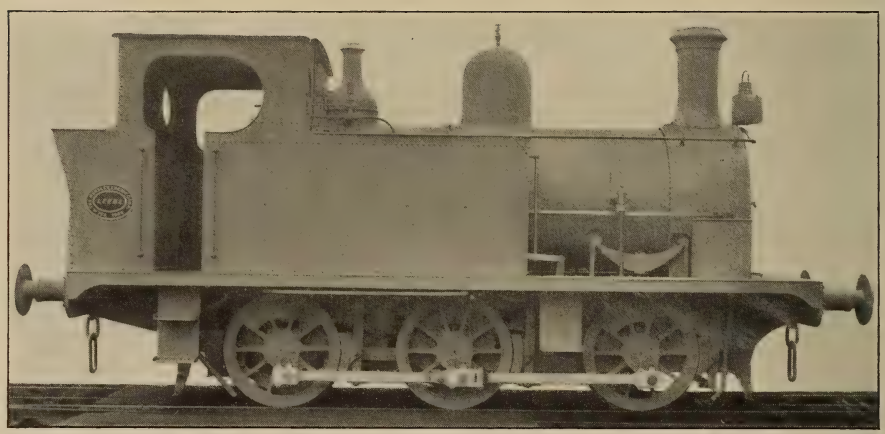


FIG. 28.—A LARGE SIDE-TANK ENGINE BUILT BY THE HUNSLET ENGINE CO., LTD., LEEDS

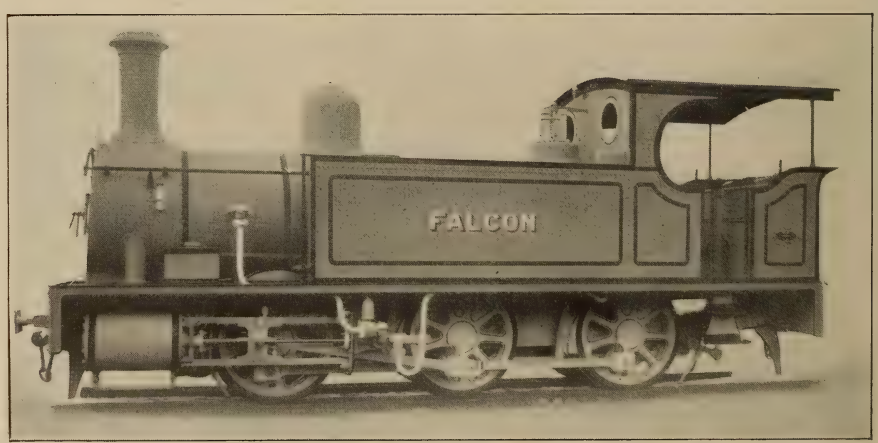


FIG. 29.—A SIDE-TANK ENGINE BUILT BY THE BRUSH ELECTRICAL ENGINEERING CO., LTD., LOUGHBOROUGH, ENGLAND

engines is excellently illustrated by the fact that there have been cases where some of them have tumbled off trestles, and others have run away down 8 per cent. grades, with heavy trains, bringing up against other locomotives, and in no case with any damage that kept the engines from starting to work again as soon as they were put on the track, the only injuries being confined to the cab, and a cracked bumper and dented footboard.

Fig. 19 shows a favourite form of American locomotive for usual contracting work,—not specially heavy, —particularly where it is necessary to haul locomotives quite a long distance over country roads to the place where they are to be used.

On the European Continent, most contractors' engines are fitted with side tanks, and there is a great similarity in general design, whether the engines are of French, German, Swiss, or Belgian origin. Four such engine are shown here. The engine represented in Fig. 17 is a small one built at the Decauville Works, of Petit-Bourg, France. This firm is noted as builders of light railway and tramway plant, and of contractors' material and machinery generally. Fig. 20 shows a useful class of engines which is now built in large numbers by the Arthur Koppel Co., of London, Berlin, and New York.

The large four-wheeled engine shown in Fig. 22 is a representative engine built by the Hannover Machine Works, and is typical of the average work of most German firms. The employment of the ordinary link valve motion, or of the Allen straight link gear arranged outside the wheels or return cranks, is curiously common for these Continental engines, and that notwithstanding the fact that the Walschaert valve gear is not only most extensively used in European countries, but is also the most suitable for outside fitting.

As a concluding example of a German four-wheeled engine, Fig. 23 shows a powerful engine having large side tanks built by the Hohenzollern Locomotive Works, of Düsseldorf. This engine, it will be noted, is provided with low central buffers for dealing with mine "tubs" and other small vehicles, and with standard spring buffers for use when hauling or shunting main railway trucks and vehicles.

So much space has been devoted to a consideration of four-wheeled contractors' locomotives that six and

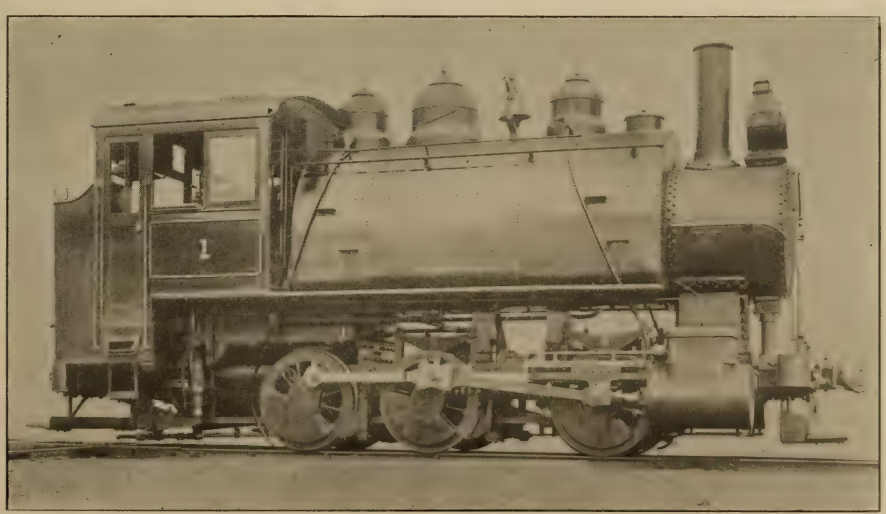


FIG. 30.—A SIX-WHEEL ENGINE BUILT BY THE ROGERS LOCOMOTIVE WORKS, PATERSON NEW JERSEY, U. S. A.

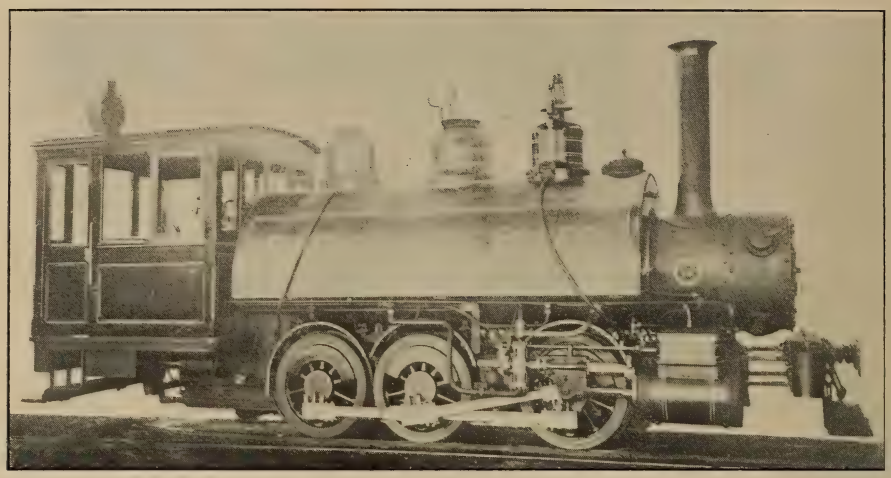


FIG. 31.—A SIX-WHEEL ENGINE BUILT BY THE BALDWIN LOCOMOTIVE WORKS, PHILADELPHIA

FIG. 32.—A FOUR-COUPLED, TRAILING BOGIE LOCOMOTIVE FROM THE WORKS OF MESSRS. HUDSWELL, CLARKE & CO., LTD.

eight-wheeled engines will have to be treated somewhat more briefly, and this can be done the more easily owing to the fact that large engines of these types correspond more or less closely with standard railway practice. They are not so characteristic of the contractors' locomotive building industry, though, of course, such engines embody individualistic features to the same extent as do the four-wheeled engines.

As regards the use of saddle or side tanks, practice is about evenly divided. Usually such engines have outside cylinders, but many British engines have the cylinders located between the frames. Fig. 24 shows a powerful saddle-tank, outside cylinder engine built by Messrs. Andrew Barclay Sons & Co., of Kilmarnock, Scotland, for the Frodingham Iron & Steel Company, Ltd. Fig. 26 illustrates a large inside cylinder, saddle-tank engine built by the Hunslet Engine Company, Ltd., of Leeds. In Fig. 25 a somewhat smaller type of saddle-tank engine built by Messrs.

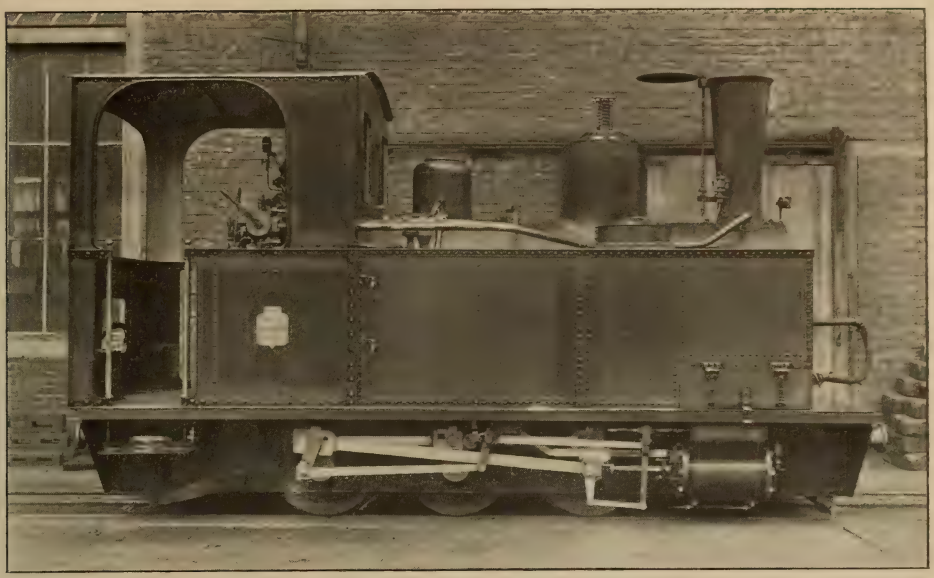


FIG. 33.—A SIX-COUPLED ENGINE BUILT BY THE DECAUVILLE WORKS, PETIT-BOURG, FRANCE

Hudswell, Clarke & Co., Ltd., of Leeds, is shown, the engine being adapted for 36-inch gauge.

When fitted with side water tanks, especially with inside cylinders, these engines can be made very neat in design, as evidenced by Figs. 27, 28, and 29, which show engines built respectively by Messrs. Andrew Barclay Sons & Co., Ltd., the Hunslet Engine Company, Ltd., and the Brush Electrical Engineering Company, Ltd., of Loughborough, England.

In American practice the engines with six coupled wheels correspond very largely in general features with the larger types of four-wheeled en-

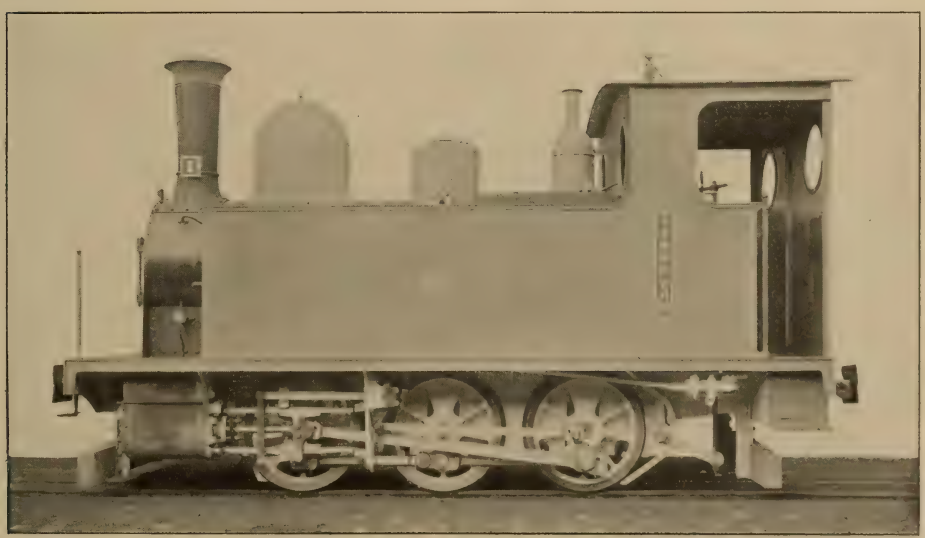


FIG 34.—SIX-COUPLED SIDE-TANK ENGINE BUILT FOR CHINESE SERVICE BY THE SOCIETE ANONYME DE ST. LEONARD, LIEGE, BELGIUM

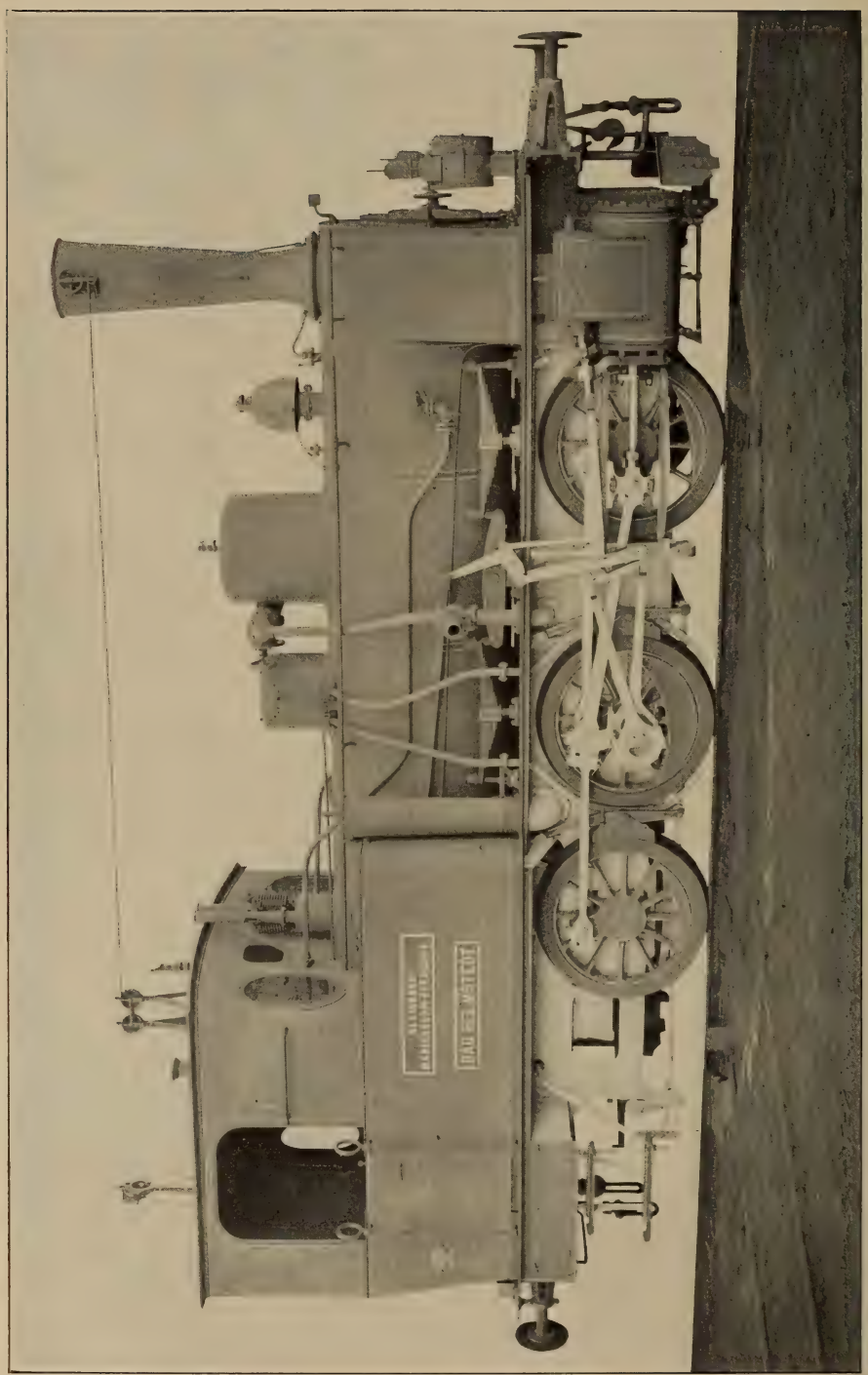


FIG. 35.—SIX-COUPLED ENGINE BUILT BY THE HANNOVER MACHINE WORKS CO., HANNOVER, GERMANY

FIG. 36.—CONDENSING TANK ENGINE BUILT BY THE HUNSLET ENGINE CO., LTD., LEEDS

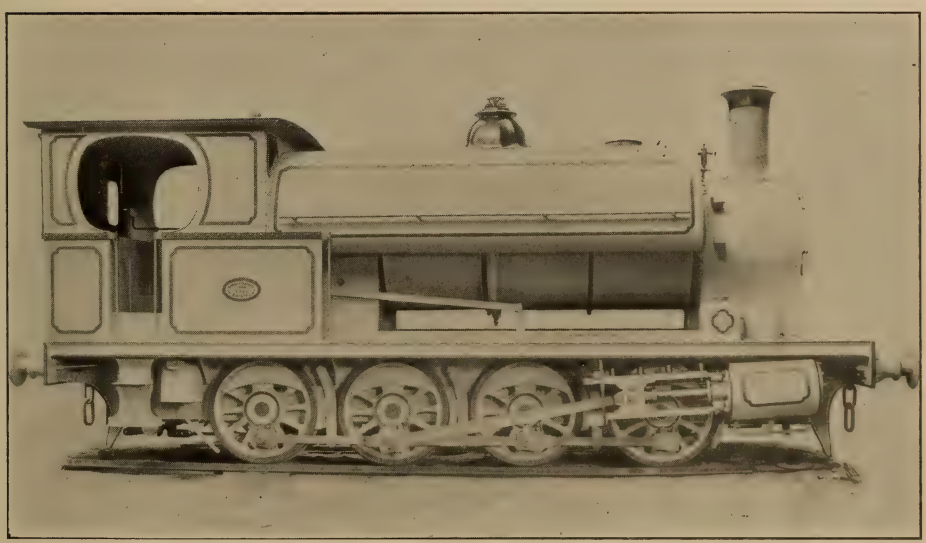


FIG. 37.—AN EIGHT-COUPLED SADDLE-TANK ENGINE BUILT BY THE AVONSIDE ENGINE CO., BRISTOL

gines. As examples of such engines Figs. 30 and 31 show engines built respectively by the Rogers Locomotive Works, of Paterson, N. J., and the Baldwin Locomotive Works.

As already stated, side tanks are most generally employed in European contractors' locomotives. The engines shown in Figs. 33, 34 and 35 are of that type. In each case the cylinders are outside the frames, inside cylinders being very seldom or never fitted.

The engine shown in Fig. 33 has outside frames and outside cylinders, and is adapted for narrow-gauge work. This engine is built at the Decauville Works.

Fig. 34 represents an engine built by the Société de Saint-Leonard, of Liège, Belgium, for service in China. In this engine, the very unusual

practice of driving the rear one of three axles is employed.

In Fig. 35 is shown a six-coupled engine built by the Hannover Machine Works Company. This engine, which is fitted with outside Allen valve gear, is typical of a very large number of Continental contractors' locomotives.

A few engines having more than six wheels, or having carrying wheels as well as coupled wheels, or possessing special features, are illustrated in the remaining figures.

Fig. 36 illustrates a powerful six-coupled, outside cylinder, side-tank engine fitted with condensing apparatus so as to adapt it for use in confined spaces and in tunnels. The builders of this engine are the Hunslet Engine Company, Ltd.

Occasionally, it is necessary to adapt powerful engines so that they will safely traverse very sharp curves; for this reason wheels other than coupled wheels are sometimes fitted, arranged either in radial axles or in a pivoted bogie frame.

Fig. 32 illustrates a large engine which is of a type rarely used except

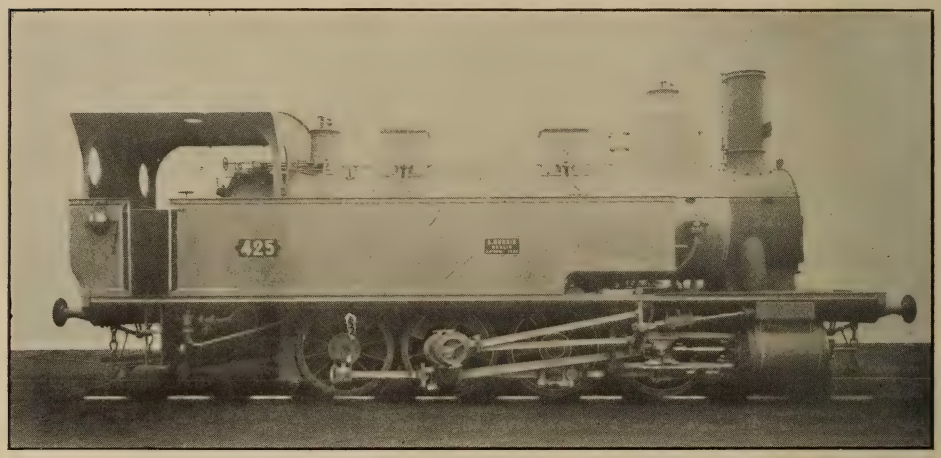


FIG. 38.—A HEAVY TANK ENGINE FROM THE BORSIG WORKS, BERLIN, GERMANY

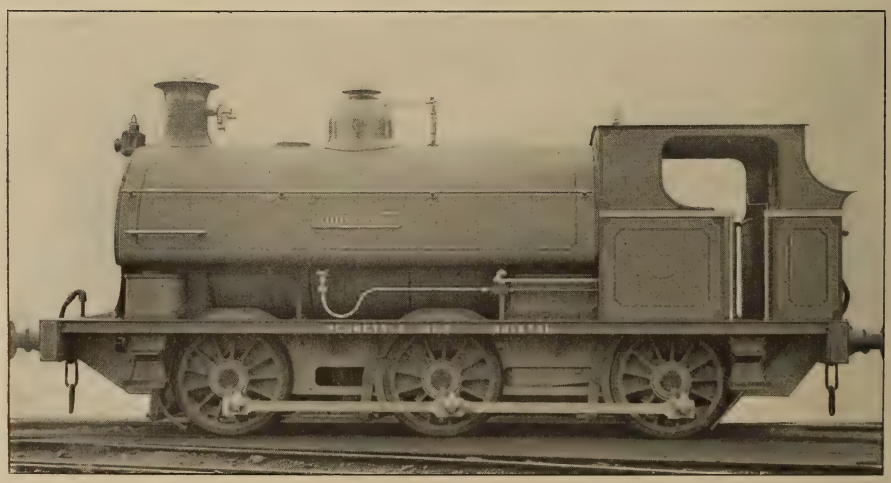


FIG. 39.—A LARGE SADDLE-TANK ENGINE BUILT FOR THE EBBW VALE COAL CO., BY MESSRS. PECKETT & SONS, BRISTOL

in main railway practice, yet it is one supplied to a large firm of contractors, and is used in railway and like construction work. The engine, in this case, has four coupled wheels and a rear four-wheeled bogie. The builders are Messrs. Hudswell, Clarke & Co., Ltd.

Fig. 37 represents a very powerful eight-coupled engine recently supplied by the Avonside Engine Company, of Bristol, for use by a coal

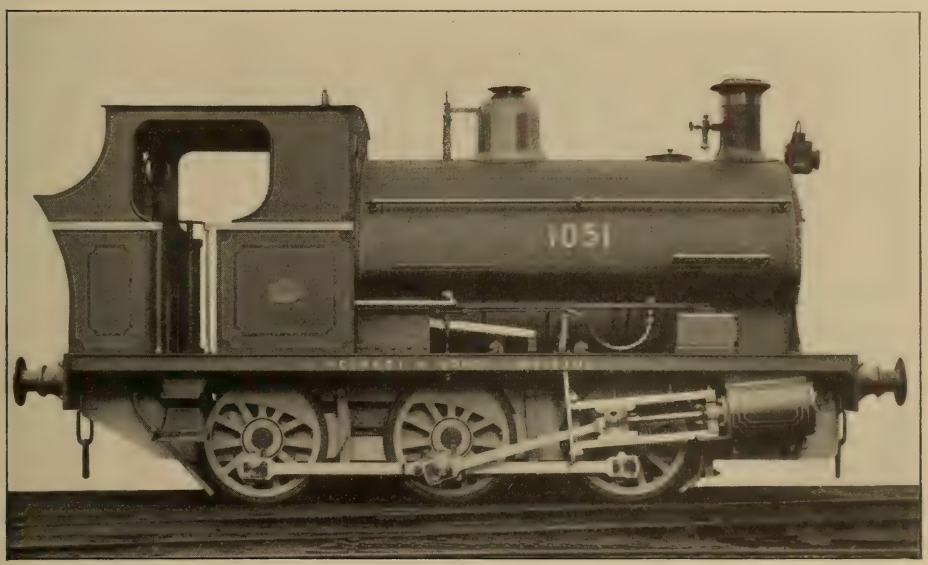


FIG. 40.—ANOTHER PECKETT ENGINE WITH OUTSIDE CYLINDERS

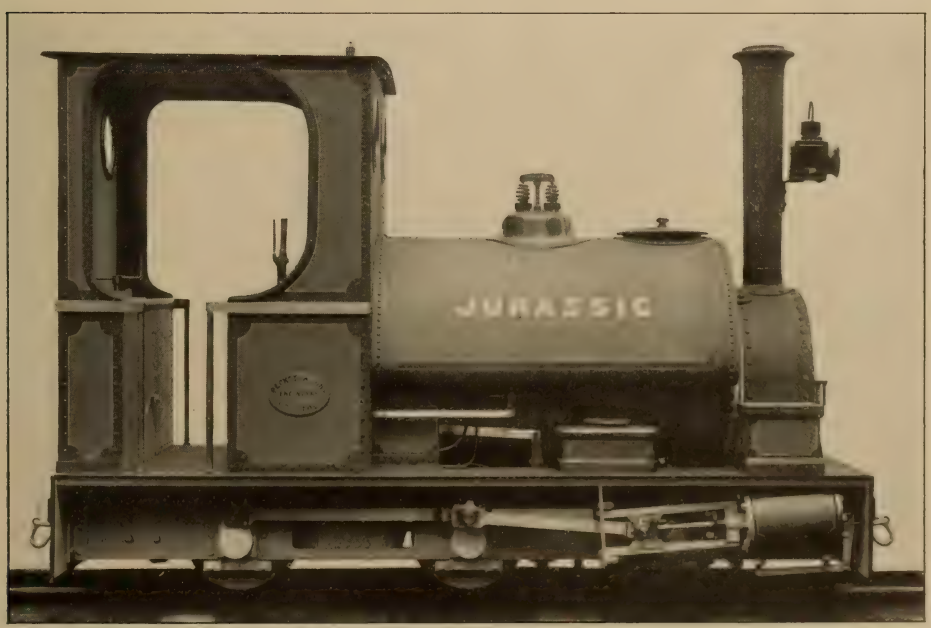


FIG. 41.—A SMALL, NARROW-GAUGE ENGINE BUILT BY MESSRS. PECKETT & SONS

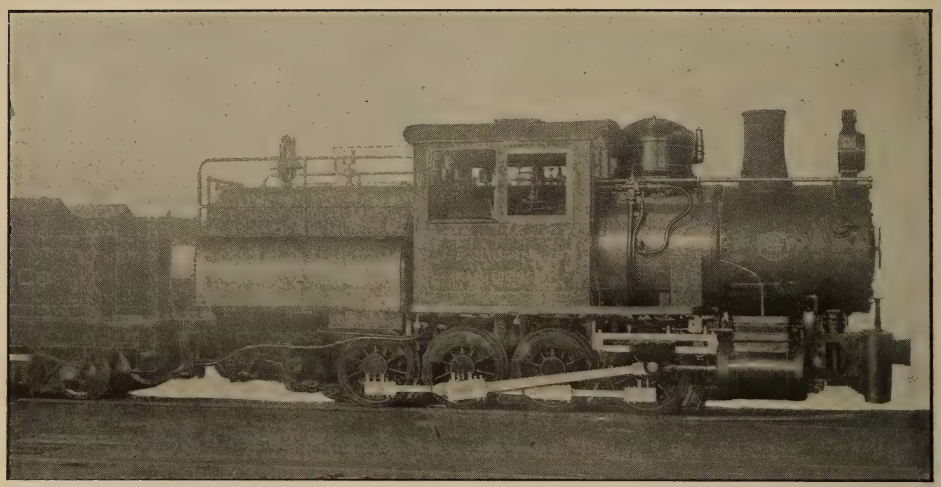


FIG. 42.—A HEAVY TENDER ENGINE BUILT BY THE BALDWIN LOCOMOTIVE WORKS, OF PHILADELPHIA

company in New South Wales. The engine is required to work heavy trains over severe gradients. Fig. 38 illustrates a large eight-coupled tank engine built by the firm of A. Borsig, of Berlin, for the Carmaux Mining Company, of France. This engine, and that shown in Fig. 38, are good examples of the requirements of private firms for engines fully equal to, or more than equal to the dimensions and power of main railway locomotives.

Fig. 39 shows a very large inside cylinder saddle-tank engine built by Messrs. Peckett & Sons for the Ebbw Vale Coal Co., in South Wales. This engine is one of the largest engines of its class, and is adapted for hauling trains practically as heavy as those to be found on the large railways. It is used to convey heavy loads for considerable distances over steeply graded tracks. It is sometimes employed for hauling workmen's trains to and from work, for which purpose it is fitted with the automatic vacuum brake. The cylinders are 18-inch diameter with a stroke of 24 inches, the coupled wheels are 4 feet in diameter, and the wheelbase is 15 feet. The weight when in working order is 48 tons. Two engines very similar to this are employed for shunting and local goods traffic by the Metropolitan Railway.

Fig. 40 shows another six-coupled engine built by this firm having the cylinders arranged outside the frames. This engine also works on standard gauge tracks, but is somewhat smaller than that just described. The cylinders are 14 inches by 20 inches.

Fig. 41 illustrates a small, narrow-gauge, six-coupled engine built by the same firm, which is interesting as an example of engines of this class. The wheels are very small, and the boiler is placed very low, so that the engine has rather a curious appearance, but it is a powerful engine proportionately to its size.

In America, where very heavy engines for private firms are used, tender engines are often employed. Fig. 42 illustrates a notable example of this practice, the engine having eight coupled wheels, a wide Wootten firebox, and an eight-wheeled bogie tender.

In the foregoing pages the writer has endeavoured to review all the notable feature of practice as regards contractors' locomotives, and would acknowledge his indebtedness to all the firms whose productions are mentioned, for the courtesy in supplying information and photographs, many of which are necessarily omitted from this article.

SMOKE ABATEMENT

A REPORT ON THE LONDON SMOKE ABATEMENT CONFERENCE, DECEMBER 13-15, 1905

By John B. C. Kershaw, F. I. C.

THE conference upon the important subject of smoke abatement, held in the hall of the Royal Horticultural Society at London last December, was a decided success. The officials of the two societies under whose auspices the conference was held, and the special committee in charge of the arrangements, gave much time and attention to the organization of the conference and of the exhibition of smoke prevention appliances which was held in conjunction with it. A very large number of invitations to have delegates or representatives at the conference were sent to municipal and other bodies interested in the black smoke problem, and over a hundred official delegates attended the proceedings. Men of distinction in the art, industrial, or scientific world, were invited to act as chairmen on the three successive days of the conference, from December 12 to December 15, and arrangements had been made for a large number of interesting papers.

The wise rule has been made also that all papers were to be taken as received, and that only ten minutes were to be allowed to the authors to introduce the main points of their papers, and five minutes to each succeeding speaker. This rule was observed with few exceptions, and in consequence there was ample time for the discussions which followed the reading of the papers at each morning's session of the conference. Three addresses and nineteen papers were in fact disposed of in the short period of three hours, and half the time of the conference was thus available for the general discussion, which, in some instances, was of great interest and of practical value.

In the following account of the conference, space will be devoted chiefly to the papers and discussions which may be supposed to be of special interest to readers of this magazine, notably to the proceedings on the second day of the conference, when the subject of "Trade and Factory Smoke Abatement" was discussed. A few remarks on the exhibits will be found at the end of the article.

The conference was to have been opened on the evening of December 12, with an address by the president, Sir Oliver Lodge. Owing to illness, however, he was unable to be present, and his place was taken by Sir William Richmond, who read to the distinguished audience the notes of Sir Oliver Lodge's address. This dealt with the connection between smoke and fog, and with the need for altering our present "barbarous methods" of burning fuel for domestic and manufacturing purposes, if any improvement in the clearness of our atmosphere and skies was to be obtained.

Sir Oliver Lodge is in favour of the plan by which coal would be purified and converted into gas at the pit's mouth, and only the fuel gas or coke used for heating purposes in our homes and industries. From the

technical point of view, the most interesting portion of the presidential address was that in which the conversion of water into steam in the ordinary steam boiler was discussed. The problem of heat transmission through boiler plates was a difficult one, said Sir Oliver Lodge. Radiant heat, in his opinion, is the chief agent in this transmission, and therefore the conditions which favour high thermal efficiency, are exactly those which most tend to prevent a smoky chimney. The address was interesting, but lost much by the absence of its author, and by the omission of the experiments and lantern slides, which were to have been shown in illustration of the various points discussed.

Wednesday, December 13, was devoted to papers and a discussion upon "Domestic Smoke Abatement," Sir George Livesey being in the chair at this session of the conference. The chairman's address, which was read in full, dealt with the use of gas for domestic purposes, and with the great increase in the number of gas cooking stoves in use in London. From figures supplied by the three leading metropolitan gas companies, Sir George Livesey calculated that 77 per cent. of the consumers are now using gas for cooking purposes, and the number was stated to be growing at the rate of 750 per week. A reduction in the price of gas would still further accelerate the substitution of gas for coal in the homes of the working classes, but in London this reduction in price was impossible, owing to the obstruction of the London County Council.

Dr. H. A. Des Voeux then gave details of his own experiences with gas for domestic heating, and stated that, with a coke-fired stove for heating the water supply, gas was nearly as cheap and much more convenient than coal for household purposes. Bed rooms and sitting rooms provided with gas fires ought, however, to be well ventilated.

A paper by Sir Charles Cookson on the use of coke as domestic fuel was then presented, the author in this paper describing the use of coke in his own house at Chelsea. The difficulty of ignition had been overcome by the use of a Bunsen gas burner under the grate,—and that of supply, if this fuel became generally used, could be overcome, in the author's opinion, by the erection of special coking ovens at the collieries for production of "charred coal."

Professor J. B. Cohen, of Leeds, followed with a paper describing the work of the Leeds Smoke Abatement Society, which was founded in 1890. This society has collected a valuable series of records relating to,—1. The nature and extent of the atmospheric impurities arising from coal smoke. 2. The methods of consumption of coal in boilers, furnaces, and domestic fire-places; and 3. The efficiency of the present system of controlling the emission of smoke. The author gave details in his paper from these records which were hitherto unpublished.

The acids of smoke were next dealt with by Dr. Samuel Rideal. The author had examined samples of London smoke, and also of the atmosphere, and he had calculated that between 500,000 and 1,000,000 tons of sulphuric acid were produced annually by the combustion of the 16,000,000 tons of coal used in the metropolis.

The injurious effect of the acid upon buildings, statuary, and iron was commented upon, and the need for action was emphasized.

Messrs. A. S. E. Ackerman and A. J. Martin presented papers dealing with the production and use of producer gas for domestic purposes, and the second of these two authors gave elaborate estimates of the cost of a scheme for supplying London with fuel gas from the distant coal fields of the North and Midlands.

The discussion on these papers was opened by W. Atkin Berry, who seconded the resolution that had been

proposed by Dr. Des Voeux, relating to the need for legislation in respect to the fire grate of domestic dwellings, and emphasized the importance of good ventilation. Mr. Horsfall referred to his experiences in German towns in relation to this question of domestic smoke abatement, and stated that for years he had used in his own house, a grate called the "Arnott" grate, which absolutely cured the emission of black smoke. Dr. Ormandy stated that the firm which he represented at the conference were saving 1000 tons of coal per week by the use of more efficient methods of burning fuel under their boilers. With regard to the proposals that gas should be used generally for domestic and industrial purposes, he would like to ask what would become of the enormous amount of coke which would remain as a by-product.

B. H. Thwaite supported the proposal of Sir Charles Cookson that by-product coke should be used for domestic heating purposes. Ernest Dowson stated that in his opinion Mond gas or water gas was not adapted for transmission to cities, or use for domestic heating, on account of its high percentage of carbonic oxide.

The papers presented on Thursday, December 14, were devoted to the subject of "Factory and Trade Smoke Abatement." The chair was occupied by Sir Wm. H. Preece, who opened the proceedings with his address. He first quoted from the Birmingham brass workers' report on their visit to Berlin, and emphasized the comparative cleanliness of Berlin as compared with London. This cleanliness, in his opinion, must be followed by corresponding gains in the physical and moral life of the community. He then traced the connection between smoke and fog, and supported Sir Oliver Lodge's terse remark, that the way to deal with black fog is "not to produce it." The improvement of London's dirty and sooty atmosphere and the solution of the fog problem were, therefore, simply a matter of improvement in the methods of burning fuel in factories and private houses of the metropolis. He went on to state that the erection of large electric generating stations and the use of gas for motor purposes would solve the difficulty as regards factories, and that the use of electric radiators would avoid the smoke nuisance from private houses. His address was closed with a protest against legislative interference and with the plea for common sense and practical methods of dealing with this question.

The first regular paper on Thursday was contributed by Commander W. F. Caborne, and dealt with "Stoking and Smoke Abatement." The paper emphasized the importance of the aid of trained and skilled stokers in all attempts to obtain smoke abatement. In the author's opinion the personal equation is of paramount importance. The recently published foreign office report on the laws in force against smoke emission in foreign countries, was then quoted from, in order to prove that this view is also held by those who have studied this question abroad. The Prussian Government had, in fact, taken up the question in a very practical manner, and had appointed traveling instructors, paid by the State, for the education and training of stokers. The author thought that in Great Britain, similar work was highly necessary, but that it could be better undertaken by the municipal authorities in the large towns.

In closing, Commander Caborne stated that if this system of training were properly carried out and certificates were granted to the properly trained men, the results obtained would greatly mitigate the nuisance arising from smoke and fog, and would, at the same time, save much money now wasted by the imperfect combustion of fuel.

Dr. Rideal presented a second paper, based upon replies furnished

by manufacturers who had been successful in securing smoke abatement in their own factories. A circular letter was issued by the London Coal Smoke Abatement Society in February, 1905, asking sixty-three firms for a description of the methods used in their works. Replies were received from forty-two, and of this total, thirty-two consented to the publication of the information contained in their letters. The details of these replies were summarized in Dr. Rideal's paper.

The general opinion of all the firms was, that skilled and careful stoking was of paramount importance for obtaining any reduction in smoke emission, even in those cases where mechanical stokers or other devices for promoting fuel economy were in use. Eighteen firms reported that they were using mechanical stokers, while fourteen reported that they were using hand firing. Only three firms had substituted gas engines for steam plant in their works.

A paper entitled "The Artificial Production of Persistent Fog" was then read in abstract by the Hon. Rollo Russell. The author pointed out that the particles of soot and other solid matter in town fogs tended to delay their dispersion, since these particles hindered the penetrating power of the sun's rays. The creation and maintenance of a black London fog followed the retention of this solid matter within a comparatively cold layer near the ground.

The extension of the suburbs around London, while it lessened the area of open fields and the tendency to produce local white fogs, increased, however, the consumption of coal, and therefore the area over which black fog might be expected to extend. The darkest fogs had occurred in London on Sundays and Christmas Day, when the largest number of domestic fires were in use. The extension of the use of gas for cooking and heating purposes would, therefore, tend to reduce the fog and smoke nuisance in London, while in the meantime some mitigation of the trouble might follow from the use of more intelligence and science in the management of the domestic grate.

John B. C. Kershaw followed with a brief abstract of his paper on the aims and work of the Hamburg Smoke Abatement Society. Some details of this society will be found on page 113 of the December issue, 1905, of this magazine. It is, therefore, unnecessary to repeat them here. Mr. Kershaw stated that 150 firms and 420 boilers are now controlled by the scientific experts of this organization, and that the numbers are still growing. The experiences of the Hamburg Society showed what could be achieved by a voluntary organization of steam users having as their object, smoke abatement and fuel economy. The author closed his paper by expressing the hope that the smoke abatement societies of London, Leeds, and Sheffield would take the lesson of Hamburg to heart and would reorganize themselves upon lines which would prove of greater service to the manufacturing community, than those upon which they were at present based.

Joseph W. Lovibond next gave a brief explanation of his paper upon "The Precautions Necessary for Making Reliable Observations of Smoke Densities." This paper was of a highly technical character, and in it the author described the construction and principles of a new instrument, invented by himself, for observing smoke density. This instrument and its methods of use were exhibited at the meeting.

The final papers taken up at Thursday's session were contributed by Arthur Rigg, and by Miss M. Agar, and related to the effects of smoke and fog upon plant life. Instances were given of the harm done to plants, shrubs, and trees in the city of London, by the dirt and soot deposited upon them during black fogs, and it was stated that the leaves of

plants in these localities required frequent washing in order to keep the plant alive.

The discussion was opened by Scott Moncrieff, who referred to a discussion in which he took part in 1880, and to a proposal made by him that all coal should be partially deprived of its gaseous matter at the gas works, and that the residual coke only should be used for domestic "heating." This proposal was not carried out, nor a similar one made by the late Sir William Siemens, but its revival at the present day by the authors of some of the papers read at the present conference, showed that it was one of the most likely methods of solving the smoke problem.

J. P. Gibson, of the Public Health Committee, of Edinburgh, then read some notes, supplied by the city engineer, regarding the action taken to suppress smoke in the northern capital. Smoke has been greatly reduced in that city by the efforts of the sanitary inspectors, who regularly visit the works and factories and instruct the stokers in the proper performance of their duties.

J. Geldert, of Bradford, stated that he had been placed in charge of the steam-raising plant of the Bradford Dyers Association, and that a saving of 33 per cent. in fuel had resulted from the scientific methods of boiler working and supervision now in use in the works of that association. He disagreed with Commander Caborne concerning the value of machine stoking, and stated that when used with discretion and common sense, mechanical stokers could be adapted to all requirements as regards steam, and to all classes of fuel.

Dr. Ormandy supported Mr. Kershaw's proposals as regards the work of the smoke abatement societies. He disagreed with Commander Caborne's remarks on mechanical stokers, and stated that at the works which he represented, the mechanical stoking plant gave every satisfaction. Mr. Macauley, chief smoke inspector of the Liverpool Corporation, dwelt on the injurious constituents of smoke, and stated it as his opinion that manufacturers would not take active interest in smoke abatement until it was proved to them that smoke meant loss of fuel, and that its suppression was allied with fuel economy.

Mr. Groves, chief engineer of the Central London Railway, spoke as the representative of the London power companies, and gave details of all the experiments they had made in the steam-raising plant of the generating station at Shepherd's Bush, in order to obtain more perfect combustion of the fuel under their boilers. The thermal efficiency of their boiler plant was now 74 per cent.

Bailie Anderson, of Glasgow, as chairman of the health committee in that city, gave details of the work carried on by the smoke inspector in Glasgow, and stated that these officers of the municipality, who were trained engineers, gave advice to manufacturers, and also assisted in training stokers in their duties. Stoking was, however, underpaid work, and no great improvement could be attained until this fact was recognized and remedied. He closed his remarks by recommending that all municipalities should take up the work on lines similar to those followed at Glasgow, and that manufacturers should be interested in the question of smoke abatement and not be persecuted by ill-advised prosecutions.

Dr. Butler, medical officer of health for the Willesden Urban District Council, was the last speaker at this session, and gave some particulars of the steps taken in the district under his charge, to obtain abatement of a very urgent smoke nuisance. A large central station had been emitting clouds of black smoke day after day in the summer of 1905, and he was convinced that it was only the action of his council in instituting prosecutions under the London, 1891 acts, that had led to any improvement

in the methods of burning the fuel under the boilers in that station, and to some abatement of the nuisance complained of.

The last day of the conference was devoted to papers and a discussion on "Administration, Legislation, and Necessary Reforms." Sir William Richmond occupied the chair on this occasion and delivered an interesting address on the enormous damage done by smoke and fog to the treasures of the metropolis. The chairman was very caustic in his references to the value of royal commissions and legislative talk in connection with the subject, and stated it to be his conviction that until the public had been educated sufficiently to recognize the seriousness and importance of the question, nothing would be done. Combined action on the part of the smoke abatement societies, and of those attending the present conference was, therefore, required to force this question to the front, and to produce the required public opinion upon which further legislation could be based.

Papers upon various aspects of the subject for the day, were then contributed by Sir John Ure Primrose, of Glasgow; Julian S. Corbett; Joseph Hurst; Lawrence W. Chubb, secretary of the Local Smoke Abatement Society; T. G. Dee, and W. Nicholson, of Sheffield.

Messrs. Dee and Nicholson are both smoke inspectors, and gave some account of the difficulties met with in making observations and in obtaining prosecutions under the public health act. Mr. Corbett and Mr. Hurst dealt with the legal aspects of the demand for reform of the existing laws, and Sir John Ure Primrose's paper was a plea for a systematic analysis of the air of towns, and for the consolidation of the laws dealing with smoke emission.

The paper of the secretary of the Coal Smoke Abatement Society was in the nature of a report based on the returns furnished by local authorities, with regard to the carrying out of their power and duties in the matter of smoke nuisances.

After some discussion, the following resolution was adopted:—

"That it is desirable to consolidate the various societies and bodies throughout the Kingdom, having for their object smoke abatement, and that the London Coal Smoke Abatement Society be requested to take the necessary steps with that end in view."

The Smoke Abatement Conference of 1905 has, therefore, ended without any attempts to institute or hurry on unwise legislation, but has decided to consolidate the existing societies and bodies interested in smoke abatement, and to urge these to carry on with greater activity the work of educating the general public and the manufacturing community as to the great importance of this question. The writer regards this decision as most wise, and he considers that more good and greater progress is likely to result from it than from any other proposal or resolution placed before the conference.

Legislation is useless if it is in advance of public opinion; education is what is at present most required. Educate manufacturers to see that smoke emission means waste, and that smoke abatement means economy, and they will probably form for themselves societies on the lines of the Hamburg Smoke Abatement Society, and thus make outside help or interference unnecessary. As Sir William H. Preece pointed out at the end of his address, manufacturers are not fools, and if they are shown that they can save money by smoke abatement, they will save it.

The exhibition of smoke-preventing and other fuel-saving appliances, held in the large hall of the Horticultural Society's Building, attracted much attention. Over fifty firms exhibited their specialties or manufactures, and a large number of awards were made in connection with this exhibition. The following firms were

awarded silver medals for their exhibits:—Messrs. E. Bennis & Company, Ltd., for their machine stoker and compressed air furnaces for Lancashire boilers; also for their improved chain-grate stoker; the Gas Light & Coke Company; Messrs. Meldrum Brothers, Ltd., for refuse destructors with forced draught furnaces; the Power Gas Corporation, for Mond gas plant with ammonia recovery apparatus; the Westminster General Electric Supply Corporation, and the St. James & Pall Mall Electric Lighting Company, for electric lighting and cooking appliances.

Twenty-three bronze medals also were awarded at this exhibition.

Current Topics

It is a question if the advantages of recording ammeters and voltmeters in electric generating plants are as widely appreciated as is desirable. In many plants an attempt is made to estimate the output and variations by hourly or half-hourly readings of the indicating instruments. This is always burdensome and calls for a large amount of electrical work in the course of a year. The usefulness of a complete automatic record of the current and voltage variation is beyond question when the performance of the plant is analyzed. When extensions or consolidations are contemplated, the existence of continuous daily records is a great help to the consulting engineer, and in many instances saves the time and expense of making test readings over a protracted period. There is nothing like an automatic load curve to exhibit the 24-hour performance of a given installation in commercial operation.

The question of how best to obtain immunity from the losses due to lightning is one of the gravest that now confronts fire underwriters everywhere, and notwithstanding that these interests have able men at work upon the best solution of the problem, there is little doubt that the advice and co-operation of electrical engineers and competent inventors toward that end would be gratefully received. Indeed, such advice and co-operation are invited. And yet the remedy for these accidents may not be as difficult to find as it appears. The greatest difficulty may consist in the application of the rem-

edy. The statistics of fire insurance show that the claims for losses on perfectly rodded buildings are rare, and also that lightning seldom causes losses in buildings that are provided with metal roofs and well-grounded metal leaders. These statistics are certainly suggestive.

It is known that of recent years the rodding of buildings in country places as a protection against lightning has fallen into general disuse, because of a prevailing opinion that the rods are of no practical utility. This, however, may easily be an erroneous view of the matter, and if one may judge from the evident lack of skilled attention in the manner of construction, the quality and type of metal used in the existing rods, and the neglect to keep the rods in proper connection with the ground after a few years of service, innumerable instances of which neglect are observable in any farming district, as well as in the cities, a reason for the failure of the lightning rods in many instances to protect the buildings will not be far to seek. Admitting this, however, it may at the same time be remarked, in view of the great advances made during the past fifteen or twenty years in our knowledge of electric surges and oscillations, that there is no doubt that a thorough examination of the subject by experts with the object of pointing out to practical laymen the best modern methods of lightning protection, will prove of incalculable value.

A commercial war of great magnitude has been in progress for some time, and the end is certainly not in sight. The steam engine is being attacked by gas and oil; electricity is in a similar plight. The drift of competent opinion in certain directions, says "The Engineer," of London, is to the effect that electricity has seen its best day. Indisputably the improvements which have been rendered possible in gas lighting by the thorium mantle have gone far to justify the assertion which has been made that gas is the best illuminant in the world. But the incandescent electric lamp may yet be improved, or even superseded. All that can be said at present is that the future of electricity seems to lie in the field of power distribution rather than of lighting. Gas lighting would have beaten electricity out of the market some time since, if it had not been for the immeasurably greater excellence of the latter in all that concerns cleanliness, heating, and purity of air. But improvements are daily being made in gas lighting, unparallelled by anything that is going on in electricity.

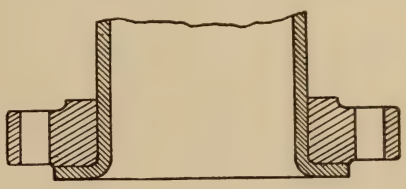
The impression that there is nothing to rival electricity for working train car lines is also no longer correct. Already we have gasoline-driven omnibuses of excellent performance, and if a gasoline motor can satisfactorily propel an omnibus on a highway, it, no doubt, can do still better in driving a car on rails. As a matter of fact, gasoline railway motor cars have latterly been built in numbers and put into service in different places.

If, then, argues "The Engineer," electricity should find in petrol or in some other form of explosive engine, such, for example, as the Diesel, a rival which could take its place on the tramway, while, for lighting, gas would in the future hold its own, it is evident that the demand for electricity would diminish instead of growing, and a very considerable reduction in the price charged for it would become imperatively necessary. There are not wanting, indeed, signs that the reduction is contemplated. So the rivalry goes on between steam, electricity, gas, and

mineral oil. Up to the present the competition has all been for the best, in the sense that it has stimulated invention and experiment, and improvements have followed which will in the ultimate end be for the good of the nation.

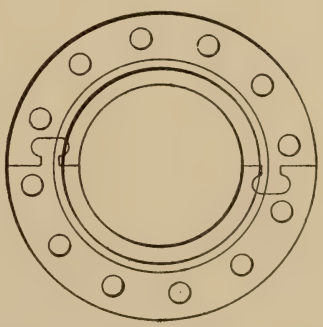
THE claim was recently made in connection with one of the many wireless telegraph announcements that by means of a new magnetic detector and transmitter over 100 words per minute could now be flashed, which, it was added, was three or four times the speed of the ordinary telegraph or cable, while the cost per word was less than half the cable rate. This statement was, doubtless, founded on the report that Marconi expects to obtain a speed of 100 words per minute with his magnetic detector, which expectation may some day be realized. In the present state of the art, however, 25 or 30 words per minute over comparatively short distances, say 200 to 300 miles, is the utmost speed attainable by wireless telegraphy. Furthermore, a speed of 100 words per minute by the ordinary wireless spark transmitter is not yet practicable; and if it were, it would be impossible to receive 100 words per minute, unless the variations of current set up by the detector were sufficiently powerful, at that rate of speed, to operate a Morse relay, to permit the reception of signals automatically. It is safe to say that such a detector has not yet been devised. The maximum speed at which telegraph operators can receive signals by sound is not more than 40 to 55 words per minute. An announcement, therefore, which, like the one in question, is capable of conveying the impression that a speed of 100 words is now being flashed by wireless telegraphy over long distances, is obviously misleading.

A GOOD form of flanged joint recently recommended by James Acton Miller for pipe lines for hydraulic work, consists in flanging out the end of each pipe and bringing the two abutting ends of pipe into direct contact. The flanges proper,—or rather collars they should be called in such a case,—abut against the flanged-out



A GOOD FORM FOR A FLANGED JOINT

pipe ends and fit loosely instead of being screwed on the pipe or welded. The upper one of the annexed diagrams, reproduced from "The Iron Age," illustrates the joint very well. The second diagram represents what is probably the newest thing in piping,—a divided flange, to be used



A DIVIDED FLANGE THAT DOES NOT HAVE TO BE SLIPPED OVER THE END

with the flanged-out ends just mentioned. It is just as strong as a solid flange and is very convenient to use in cramped quarters where piping is often placed or in passing through a wall to save cutting a large hole or to save the slipping of the solid flange back and forth on the pipe while it is being handled, mashing fingers, and being in the way generally. The divided flange can be placed around the pipe at any time and made up the same as if solid.

In contrasting European and American foundry methods in a recent paper before the New England Foundrymen's Association, Dr. Richard Moldenke, who for years has been closely identified with the foundry industry, remarked that perhaps the first thing which strikes the European foundryman who is visiting an American plant is the great stress laid upon system and organization in the strictly modern establishments. The European founder, with his more varied work of smaller aggregate tonnage, casts his pieces one by one and finishes each with the assembling following directly. The American, with an eye to the finer economies, prefers to put through an order of anywhere from a dozen to thousands of pieces of a kind, finishing them up for stock and stealing the parts required for sales and promises. As the stock in the warehouse gets below a certain minimum, another shop order goes in to fill up the gap. As a consequence the work is always produced at the cheapest rates possible. Dr. Moldenke said that he had known single orders of 100,000 castings of some 30 pounds each given with simply a blue-print of the casting attached to the document. Many times the quantity has been 30,000 to 60,000, which meant that economical work could be done there if anywhere. Actually the figures at which these castings were carried out would be astonishing.

Apart from the use of moulding machines to turn out these classes of castings cheaply, there is a noticeable tendency to economize shop room, and hence moulds are piled as high as they can be conveniently poured. It may be objected that this method oftentimes produces more sprues per pound of casting than the old way and that if trouble comes, a stack of moulds will be ruined instead of only a single one. Yet this system has been found to pay wherever tried, and the getting of more tonnage for a given floor space is bound to spread. The idea, however, should be followed out to its logical end wherever work is made in sufficient quantity. This would seem to be the stacking up of the moulds in fairly deep foundry pits, the iron being brought in large ladles by traveling crane and poured from the bottom of the ladle. Suitable variations in the method can naturally be devised for given cases, but the idea remains the same—to get the greatest tonnage for a given floor space in order to save investment and cost of output.

A wider use of the direct-metal process stands first in the list of things which Dr. Moldenke sees in the way of foundry progress. He does not advocate the use of the direct metal just as it is, but to have the stream of metal from the blast furnace go into large heated mixers, which means greater—in fact, more easily attained—uniformity than is ever possible with the cupola. Into this mixer there should be charged successively quantities of steel scrap which has been heated up almost to melting. This accomplishes a twofold purpose. First, it gives a reduction of total carbon without lowering the temperature of the metal in the mixer too seriously to be corrected at once by the heating method used as well as the comparatively large quantity of metal that should be in the mixer all the time. The first result is the making of a high grade cast iron. This iron should be good enough for all the purposes the process could be used for, such as the making of pipe, tunnel segments, ingot moulds, etc. The second effect of the addition of the preheated steel scrap is that the problem of "kish" is done away with. This is the bugbear of the direct-metal foundry, and in fact has retarded the introduction of direct metal for important work so much that at one time it was

thought out of the question to think of ever going back to this ancient way of making castings. The result of this tendency will be that blast furnaces will be located wherever the raw materials not only are favourable, but where there is a good shipping point for pipe, possibly car wheels and not impossibly malleable castings for car work. The furnace proposition will then become one of allied industries to give an outlet for the pig iron made which will fit these uses, and all the pig iron not of composition to go into the various mixers will be put upon the market. While this seems visionary, it is nevertheless a fact that one very large combination is about to break ground for just such an establishment and we may hear from direct-metal pipe very soon.

THE progress made in recent years with gas engines of increasing power naturally raises the question whether they may not take the place of steam engines even in large ships. No one, remarked Sir William H. White not long ago in a presidential address before the Institution of Civil Engineers, can fail to be attracted by the prospect of possibly dispensing with the use of steam as an intermediary, and directly using gas for internal-combustion engines. Of course in sea-going ships questions of importance arise as to the power of covering long distances, and the arrangements for generating or storing gas, as well as obtaining adequate supplies of coal or oil. We are on the threshold of this subject; and it seems probable that a great deal more must be done on land in the development and use of gas engines of very much greater power than any yet constructed, before the steam boiler disappears from ships. Experiments of the character needed must not and need not be conducted on board ships. It may be that Sir Frederick Bramwell's prediction is correct, and that in less than 30 years the use of gas engines will be almost universal. Only time can settle this question; but one thing is certain, naval architects and marine engineers will welcome and utilize any system which simplifies internal arrangements and minimizes weight and space. Enthusiasts dream of a time when gas turbines instead of reciprocating engines shall be brought into use. But at present there is a disposition to believe that very serious, if not insuperable, difficulties lie in the way of this system of utilizing power. However this may be, no initial steps seem to have been taken to practically realize the idea.

AMONG the problems which the marine gas engine introduces are many that belong to the engine itself, while others belong to the producers and the plant as a whole. The most serious of the latter, according to "The Engineer," of London, is the weight of the gas generator itself and the apparatus for cleaning the gas before it is fit for consumption in an engine cylinder. A recognized authority on gas producers says that he sees no insuperable difficulty in the way of making suction producers of 500 or even 1000-H. P. capacity; but at present nothing of the kind suitable for marine purposes has been built, and we are driven back upon quite small plants for the purpose of comparison. Even these, however, are of interest. A suction producer of 150 H. P. stands about 10 feet high, and occupies a space of about 8 feet by 8 feet, and weighs, charged with fuel, between 8 and 9 tons. The steam generating plant for a steam engine of about the same power would weigh certainly twelve to fourteen tons without water, and the boiler alone would occupy as much space as the producer, leaving the accessories out of account. On the other hand, the steam engine would weigh only about 6 tons, possibly not a third of the weight of

the gas engines as at present made. In larger size, however, the disproportion might be less. Designs have been got out for an engine of 500 H. P. weighing 54½ tons, and fed by a producer weighing 17 tons; whilst engines of 250 H. P. weighing 27 tons, with generators weighing 8 tons, have actually been made. It must be remembered, however, that whereas every marine engine must carry with it always a large volume of water, the amount that is required by the gas producer is but small, and we shall not be very far wrong if we assume that when makers have turned their attention seriously to the design of producers and engines intended especially for ship use they will be able to give us a horse-power for plant weighing less, occupying less space, burning cheaper fuel, and demanding fewer hands to operate it. While, therefore, he would be a rash prophet who would say that the days of the marine steam engine are numbered, there can be no question that a rival, which only a few years ago appeared insignificant, is assuming dangerous proportions.

In discussing screw propellers, Sir William, in the address alluded to above, said that after sixty years' experience with them it must be frankly admitted that we still have very much to learn. The theory of their action has engaged the attention of many eminent mathematicians. Very many experiments have been made on various ships fitted with propellers of different dimensions and patterns, and in some instances remarkable economies of power or gains in speed have been obtained. Model experiments on screws have been carried out on an extensive scale, and very interesting results have been obtained. Certain general principles have been estimated, and many problems at first obscure have been solved. But in spite of the theoretical researches of Rankine, William Froude, and many other eminent men, and the experimental investigations of the two Froudes, Thornycroft, Yarrow, Blechynden, Parsons and others, we have not yet established rules by which the selection of the most suitable propeller for novel types or exceptional speeds can be ensured. In some quarters there is a disposition to assert that this result is discreditable to naval architects and marine engineers, who are supposed to have advanced little, if at all, beyond the knowledge possessed by their predecessors forty years ago. These adverse criticisms ignore much valuable work that has been done, with consequent additions to knowledge, and they fail to recognize the inherent difficulties of the problem. Propeller efficiency depends upon so many variable conditions—not merely in the dimensions, form, pitch ratio, blade area, rate of revolution and water resistance to rotation, but in the movement of the water in which the screw works as affected by the form and frictional wake of the ship—that there must be a vast number of cases to be dealt with, and no general solution may be attainable. When all care has been taken and the fullest use made of available data, success is not assured in the choice of propellers when precedent is largely departed from. On the other hand, in most, if not nearly all, cases, success is eventually achieved as the result of experimental trials, although there is often a possibility that even better results might be attained if the trials were extended. This is true of all classes and sizes of ships, from the great Atlantic liner down to the torpedo boat.

Concerning the housing of workingmen in Austria, Consul Harris supplies the following interesting particulars of what is done along this line by the Wienberger brick-making establishment near Vienna. This company has built homes for about 2500 families. The houses are placed

at the disposal of the workingmen free of rent. The company not only lets the homes free of rent, but also delivers gratis the necessary fuel for heating and cooking purposes. The workingmen must pay for their own furniture and light. This very liberal system is applied only to the workman and his immediate family, which is understood to consist of only the wife and all children under 14 years of age. In case there are many children in the family, the parents of the workman or those of his wife may wait upon and look after such children as far as the local laws governing overcrowded tenements or flats will permit. This system of housing workingmen, however, forms a part of their wages, and the moment a workman leaves the employ of the company he must vacate, together with every member of his family, the dwelling which he has occupied during the period of his employment. The children of workingmen holding independent positions outside of the company's works are not permitted to live with their parents in any part of the dwellings without paying a weekly rent of 10d. per capita. This sum is regularly deducted from the father's wages. The rules in this respect are very strict. It is sufficient cause for dismissal if the head of a family attempts to dodge these provisions by even inviting some of his next of kin or some visitor to remain overnight. Each and every workingman living in such a dwelling belonging to the company is compelled to keep the living rooms, kitchen, cellar, and outhouse in a state of absolute cleanliness, and to have them aired daily. Goats, poultry, and rabbits may not be kept in the vicinity of the dwellings, and whoever in any way mars the houses or rooms renders himself liable for damages. Only a sufficient amount of fuel is allowed to be kept on hand for one day's use. The hallways and stairs are lighted at night at the expense of the company. This example, we are told, is a fair criterion of what every manufacturing establishment in Austria is striving to do.

The reasons for the gain in economy due to the use of superheated steam in reciprocating engines and turbines, are very far from being the same and an analysis of these will help to furnish an estimate of what can be expected ultimately in this direction from the steam turbine. In the case of the reciprocating steam engine, as pointed out in a paper presented a short time ago by Professor Storm Bull before the Western Society of Engineers, the gain is due to the reduction of the cylinder condensation, which is due to the difference of the temperature of the saturated steam and of that of the cylinder walls and head, which condensation is greatly intensified by the moisture in the steam adhering to the metallic surfaces. Consequently the gain is not alone due to the fact that the superheated steam is capable of giving up a certain amount of heat without being condensed, but also—and in most cases to a greater extent—because very much less heat is transmitted from the superheated steam to the cylinder than if there had been saturated steam for the same difference of temperature.

In the case of the steam turbine, this difference of temperature is necessarily very much smaller, as no exhaust steam touches the parts which come in contact with the steam on its way through the turbine. On the contrary, if the barrel of the steam turbine is well protected, the temperature of the inside of this barrel can be but very little different from that of the steam at that particular place; hence the condensation due to this cause is certainly small compared with that in the reciprocating engine. Because of the absence of moisture

on the cooler surfaces touched by the steam, this condensation will be reduced in the same ratio as for the reciprocating engine, but the difference of temperature being so small, this gain, because of the absence of moisture, can be only insignificant. However, even in the ideal case of an adiabatic expansion, condensation is inevitable if saturated steam be used, and such condensation will be prevented if the steam be sufficiently superheated so that its temperature may be lowered without its becoming saturated. In this respect the steam turbine and the reciprocating steam engine are on the same level as to the possible gain due to the use of superheated steam.

So far, the analysis has unmistakably shown that the last named motor has the advantage; but there is an additional reason for the gain in economy by the steam turbine, and that is in the reduced friction which the superheated steam encounters on its way through the turbine as compared with the saturated steam. This friction is entirely negligible in the case of the reciprocating steam engine, but because of the very high velocities utilized in the steam turbine it is a very important factor in its economy. This friction is not alone due to the motion of the steam through the various wheels of the turbine, but also to the rapid revolution of the wheels in this steam. How much the friction amounts to it is at present impossible to say, although some experimental work has been done in this direction, notably by Dr. A. Stodola, of Zurich, Switzerland; but it amounts to a good deal, and there is no question but that it is very much smaller for superheated steam than for saturated. The use of superheated steam for the reciprocating engine has been accompanied by all kinds of difficulties because of the troubles of lubrication and the expansion of the cylinder due to the high temperature. Although these difficulties have been overcome to a very large extent, ordinary practice has limited the superheat to within reasonable limits because of these reasons. In the case of the steam turbine these difficulties do not exist, so far as lubrication is concerned, and but to a very much smaller extent with reference to the expansion of the metal. It is therefore possible to use a very much higher degree of superheat for the steam turbine than for the reciprocating steam engine without any bad effects, and this in itself is a distinct advantage.

A UNIQUE application of compressed air is found at the plant of the United States Silica Company, at Ottawa, Ill., about 80 miles from Chicago, At this point, according to "Compressed Air," there is an immense deposit of silica sand of the best grade for glass making. The property has been worked for some years, and at present the excavation is about 800 feet long and 600 feet wide, with a maximum depth of about 100 feet. The cost of removing this sand and hoisting it to the plant at the surface has been steadily increasing with the depth, and recently a point was reached at which a shut-down of the property seemed imminent unless some more economical method of lifting the sand could be devised. In this crisis a contract was placed with the Pneumatic Engineering Company, a department of the Ingersoll-Rand Company, of New York, for the installation of a Harris compound displacement pump especially adapted for this particular work. Briefly, this system involves a direct displacement of the contents of a tank by air under pressure, this air being in turn returned to the compressor for recompression. Advantage is thus taken of the expansive force of the air—a feature distinguishing the Harris system from other pneumatic displacement pumps. In the Ottawa plant a sump was dug

in the lowest part of the sand-pit in which a Harris pump was installed, consisting of two steel tanks, 5 feet in diameter and 5 feet in height. Upon these are mounted the connecting pipes and valves by which the tanks are filled and discharged in alternation. The double air line of 3½-inch pipe leads to the automatic switch and compressor in the engine room on the brink of the pit. The method of excavating the sand is at present as follows:—A constant flow of water which enters the pit on all sides from springs is collected in a sump, which is the source of supply for a small duplex steam pump taking the water and discharging it through a hose and nozzle. The stream is played on the walls of the pit, washing the sand down, and the mixture of sand and water is directed into a box beside the main pump. The pump suction pipe enters this box and the partial vacuum created in the tanks draws the sand and water into the tanks, from which it is discharged by compressed air in the next cycle through the delivery pipe to the bin above. The sand mixture varies in quality from one of 5 per cent. of sand to one of 65 per cent. by weight. The average performance of the pump is 50 tons of sand alone raised per hour, or 500 tons of sand per 10-hour day. The work done by the pump will be further appreciated when it is considered that the supply of water entering from the springs is from 300 to 500 gallons per minute, all of which is discharged with the sand through the pump.

It might naturally be expected that the rapid pumping of such an abrasive material as sand would soon destroy the pump mechanism, but after an operation of several months no appreciable wear has been found on this system. On top of each tank there is a check valve, preventing the return of the material in the discharge pipe. This is of the simplest form, consisting of a rubber-covered ball resting on a ring seat, and inspection has shown that while the seats have worn, they have worn uniformly and present the appearance of a highly polished turned ring. The balls themselves show no wear whatever. The pressure-controlling valves are located in the engine room above and at no time are in contact with the material pumped. The system works continuously. During the day it pumps sand and water in mixture; during the night it pumps water alone, keeping the pit empty and ready for resumption of operations on the following day. The introduction of this method of pumping simplified the problem of removing the sand in many ways. Its operation calls for three men; the engineer looking after the compressor, who also cares for other machinery in the surface plant; the pump attendant, whose duty it is to see that the flow of sand and water is properly directed to the gathering box; and the hose man who handles the stream of water for removing the sand from the walls. The sand mixture is discharged from the pump into a reveiving bin at the surface where it is allowed to settle; the water flows off through a waste-way. The thus partially dried sand is then removed from the bins and put through the usual process of drying and separating.

A valuable time-saving feature in one large American manufacturing plant,—that of the Chapman Valve Manufacturing Company, by the way, of Indian Orchard, Mass., is a number of steam whistles with solenoid magnets attached, distributed throughout the establishment and connected to the lighting circuit. Should a long-distance telephone call come in for the manager or superintendent and the operator could not reach him at his office, she would, by pressing a button on the switchboard

the required number of times, blow his telephone number on all the whistles in the plant, and the man wanted could step to the nearest telephone and immediately get in touch with his party without loss of time. These whistles are also used as signals by the superintendent for calling heads of departments should he want them in a hurry, and ought to commend themselves for consideration in other similar places.

THE point was recently made that in view of the absence of any radically new features, during the past few years, in the design of such machine tools as lathes and planers and milling and drilling machines, even though the best available talent was engaged in this designing work, finality had evidently been reached in their development. The tools were practically perfect, it was argued; hence further progress in the general field would probably be in the direction of special tool development,—"single-purpose" tools as they have been aptly termed. In point of fact, the tide in this direction set in strongly some time ago. Even a superficial observer at the several large industrial expositions of recent years must have carried away a distinct impression of a multiplicity of special machine tools of ingenious character which had sprung into existence, clearly in response to demand. Increased output, greater economy of production—these are the ever-present modern factory dictates under which the single-purpose tool idea will continue to develop.

THERE is no logical reason why a pipe system for heating feed-water on the now much-practiced fuel economizer plan should not be applied as well to the heating of air for all the various purposes for which heated air is used—warming and ventilating buildings, for example, and drying processes in laundries, textile mills and other establishments. It is interesting, therefore, to note that such an application of the economizer principle has been made by the builders of the well-known Green economizer. The resulting Green air heater is constructed substantially like the older apparatus, except in this respect, that the path of the air through the pipes is not the same as that taken by water through an economizer. In the latter the water enters at the bottom header and passes out from the top header, whereas, in the air heater the air is forced by a fan first down through one set of tubes and up through another set, and so on, down and up again, until it leaves the heater. The air heater, like the economizer proper, is placed in the flue passages, and its performance, under recent tests, was found to be excellent.

INJECTING liquid cement, by means of air pressure, through a series of holes drilled through cellar and basement walls, in fact all underground walls, has been recommended by a German engineer as a good way of making them watertight. An ordinary hand force-pump, connected by hose with the vessel containing the cement, and a suitable delivery pipe and jet, are all that is necessary. Strictly speaking, this is simply one form of grouting, but for ordinarily inaccessible places it would seem to commend itself well. It is said to have been applied with excellent results in the case of a damp tunnel where numerous holes were drilled through the crown and cement was forced in as here mentioned. In cases where there is a considerable flow of water to contend with, the cement may be made quick-setting by adding a solution of soda to it. With this, set takes place in a few minutes.

A TRIBUTE to the importance of engineering in the Navy appeared in

"The North American Review" for January, from the pen of Admiral S. B. Luce (retired). Although unknown to the general public, Admiral Luce, while on the active list,—about twenty years ago,—enjoyed the reputation of being a fine officer of the old school, and was the author of a standard text-book on seamanship for vessels of the sailing period. He was also naval editor of "Johnson's Encyclopædia," and of the "Century Dictionary." Believing as we do that engineering in the Navy needs the help of earnest friends, we welcome the Admiral's efforts in its behalf, but we are sorry to say that we can commend only his desire for increased efficiency; the details of his scheme seem to us entirely against the trend of modern methods. As this magazine was the first one which gave prominence to the term "fighting engineer," we are naturally interested in the bitter criticism which it arouses from the Admiral. Having defined the term to suit himself, he finds it misapplied when the engineer concerned deals with machines on war vessels. He even goes so far as to call the "fighting engineer" a hybrid, and then says that the prominent characteristic of hybrids is sterility; hence such an officer must be inefficient. We fear the gallant Admiral's knowledge of naval vessels from personal contact must have ceased many years ago. It is stating only a fact, well known in the Navy, that the most accomplished of the younger line officers are those who were trained as engineers and came over into general duties under the amalgamation.

Perhaps the most remarkable of Admiral Luce's statements is that the source of all the naval engineering difficulties at the present time is the training of the engineers of the Navy at the Naval Academy. He distinctly says that "the line and staff fight was brought about mainly through the mistake of forty years ago, in giving our marine engineers a military training at the Naval Academy!" If anything were needed to prove his lack of acquaintance with actual conditions in the Navy to-day, this furnishes it. We believe his retirement occurred about fifteen years ago, so that he could not personally realize the tremendous improvement in the relations of officers of different corps which began before that time and grew steadily. This improvement, we have been informed by the men who went through it, was due almost entirely to the joint education of the young engineers and sailors at Annapolis. Common sense would lead us to expect that boys who are classmates in a great school, and trained under the same traditions would be better friends than those educated along entirely different lines, and such is the actual fact. We believe that every fair and unbiased student of naval affairs will assert that the present unsatisfactory condition of engineering in the Navy is due to the utter failure, on the part of the officers of high rank who were responsible, to make any attempt to carry out the scheme of the Personnel Law, which contemplated that every line officer should be primarily an engineer. It is worse than stupid,—it is impudent,—to blame a splendid scheme of education and training for failure to secure results, when no effort has been made to carry it out.

Naval officers are notoriously conservative, and it was perhaps expecting too much to anticipate that a scheme so radical as making every naval officer an engineer would be at once accepted by the older ones, who were in the position to do so much for or against it. The prejudice against the "mechanic" was very strong in them, and there have been those who were unkind enough to say that their failure to oppose the Personnel Law was because it carried

increased rank and pay for them, and not because they loved the plan of amalgamation. However, prejudices can not wholly prevent progress, although they may delay it, and we expect to see the essential principle of the Personnel Law, "Every officer on a modern war vessel has to be an engineer, whether he wants to or not,"* fully adopted and carried out so as to give us the highest efficiency.

* President Roosevelt, when Assistant Secretary of the Navy, as Chairman of the Naval Personal Board.

CHARLES ETHAN BILLINGS

President of the Billings & Spencer Company, Hartford, Conn.

A BIOGRAPHICAL SKETCH

IT is largely through the manufacture of drop forgings and drop-forging machinery, in which he is a pioneer, that Charles Ethan Billings won his prominent position in the industrial world. To-day the Billings & Spencer Company, of Hartford, Conn., of which he is president and general manager, is known the world over for its achievements in these branches of manufacture.

Mr. Billings comes from thoroughgoing New England stock, his father being the sturdy blacksmith of Windsor, Vt., the village where Mr. Billings spent his early years. After serving his time as apprentice to the Robbins & Lawrence Company, of Windsor, he went to Hartford and was employed with the Colt Arms Company, till the opening years of the Civil War, when he was called to the Remington works, at Utica, N. Y. There he formulated his ideas and improvements in drop forging, and through his efforts a plant was built up which increased the efficiency of labour forty fold in the production of various parts of fire-arms.

In 1865 he returned to Hartford as superintendent of the Weed Sewing Machine Company. There he introduced drop hammers for forging shuttles of one piece of metal, which reduced the cost of the shuttles one-half, and has since been universally adopted. His present company has made upwards of four millions of them.

Soon after the close of his term with the Weed Company, Mr. Billings organized the Billings & Spencer Company which, in 1870, took up drop forgings as a specialty, and soon advanced to a commanding position.

Mr. Billings' life work has been, in the main, given to the development of the drop-forging industry. He early saw the great saving of labour to be effected by this means as well as the improvement it made in forged tools and machinery. Starting from the crude efforts of several others who preceded him in that line, he brought the art up to its present high standard.

At the present time all of the best tools and parts of machines, vehicles, etc., are drop forged.

In 1895 Mr. Billings was elected president of the American Society of Mechanical Engineers, and to-day he is either officer or director in several concerns of national repute.

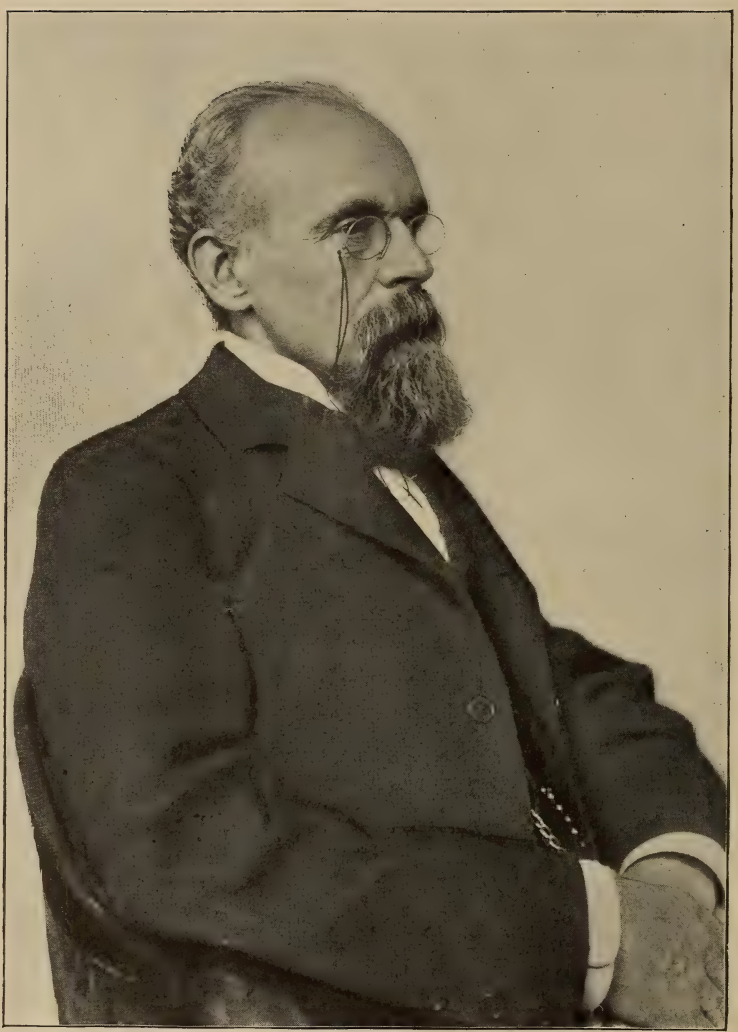


PHOTO BY THORNE, ALLEGHENY

JOHN ALFRED BRASHEAR

AMERICA'S FOREMOST ASTRONOMICAL INSTRUMENT MAKER

SEE PAGE 438

CASSIER'S MAGAZINE

VOL. XXIX MARCH, 1906 No. 5

A CONCENTRATED INDUSTRY

PRODUCTS OF THE MARYLAND STEEL COMPANY, AT SPARROW'S POINT, MARYLAND, U. S. A.

By Day Allen Willey

A PACIFIC LINER FROM THE SPARROW'S POINT YARD

ON a little point of land on Chesapeake Bay is located one of the most unique groups of industries in America. It is unique not only by reason of the diversity of its product, but because it proves how industrial activity can assume great proportions in a few years and yet have all of its branches confined within a very limited area of space.

The Maryland Steel Company, as it is termed, began operations less than twenty years ago on a tract of farming and marsh land in Maryland, known as Sparrow's Point. The company began making steel from iron smelted in its own furnaces, but the ore, limestone, and fuel had to be brought from a distance. The bulk of the ore came from the hematite deposits of Eastern Cuba, 1500 miles from the works, the coal from Western Maryland and West Virginia, and the coke principally from the Connellsville district in Pennsylvania. The fuel from the nearest mine had to be carried nearly 200 miles by rail. The chief advantage of the location was thus the facility which it afforded for receiving ore and shipping the output by water.

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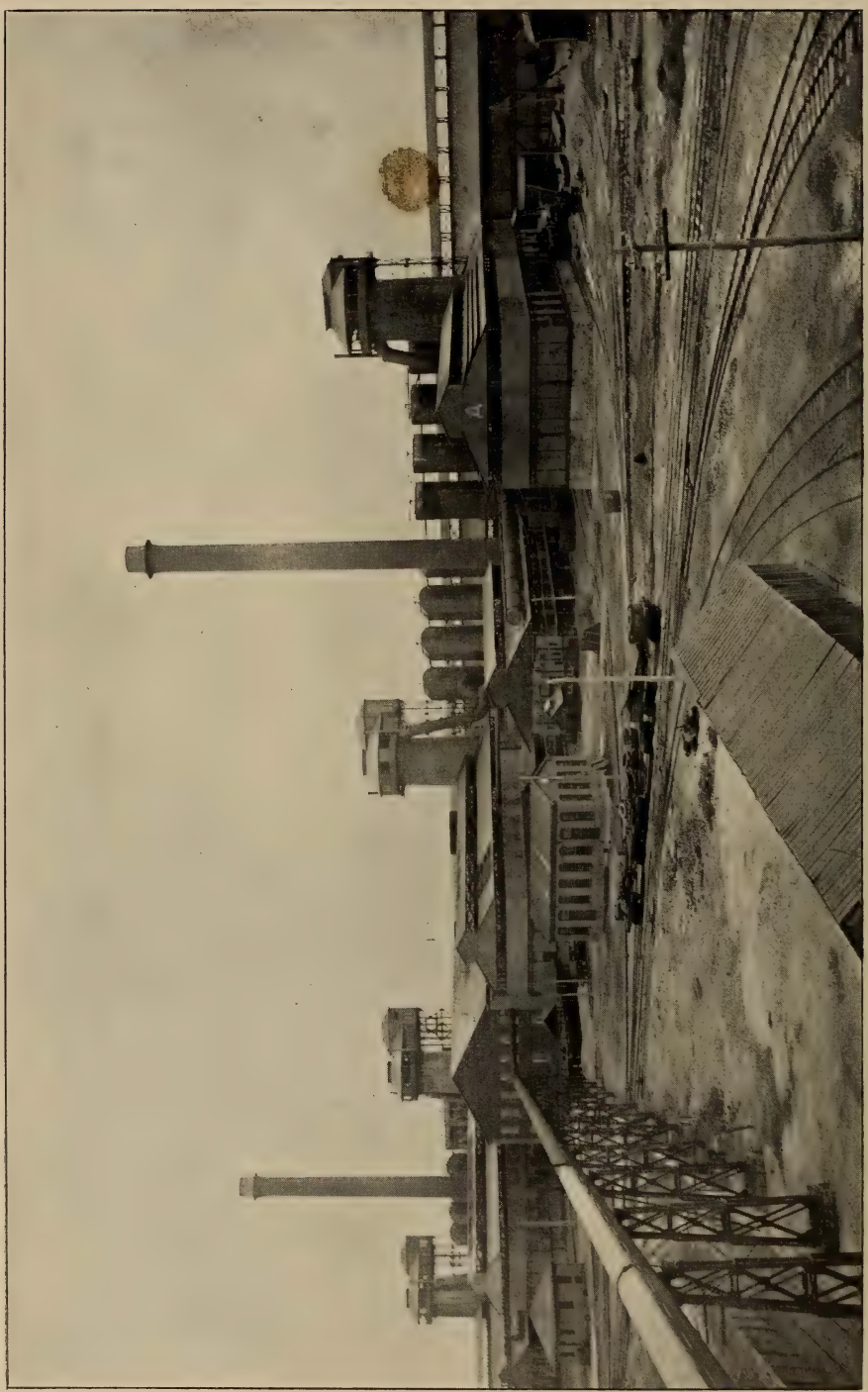
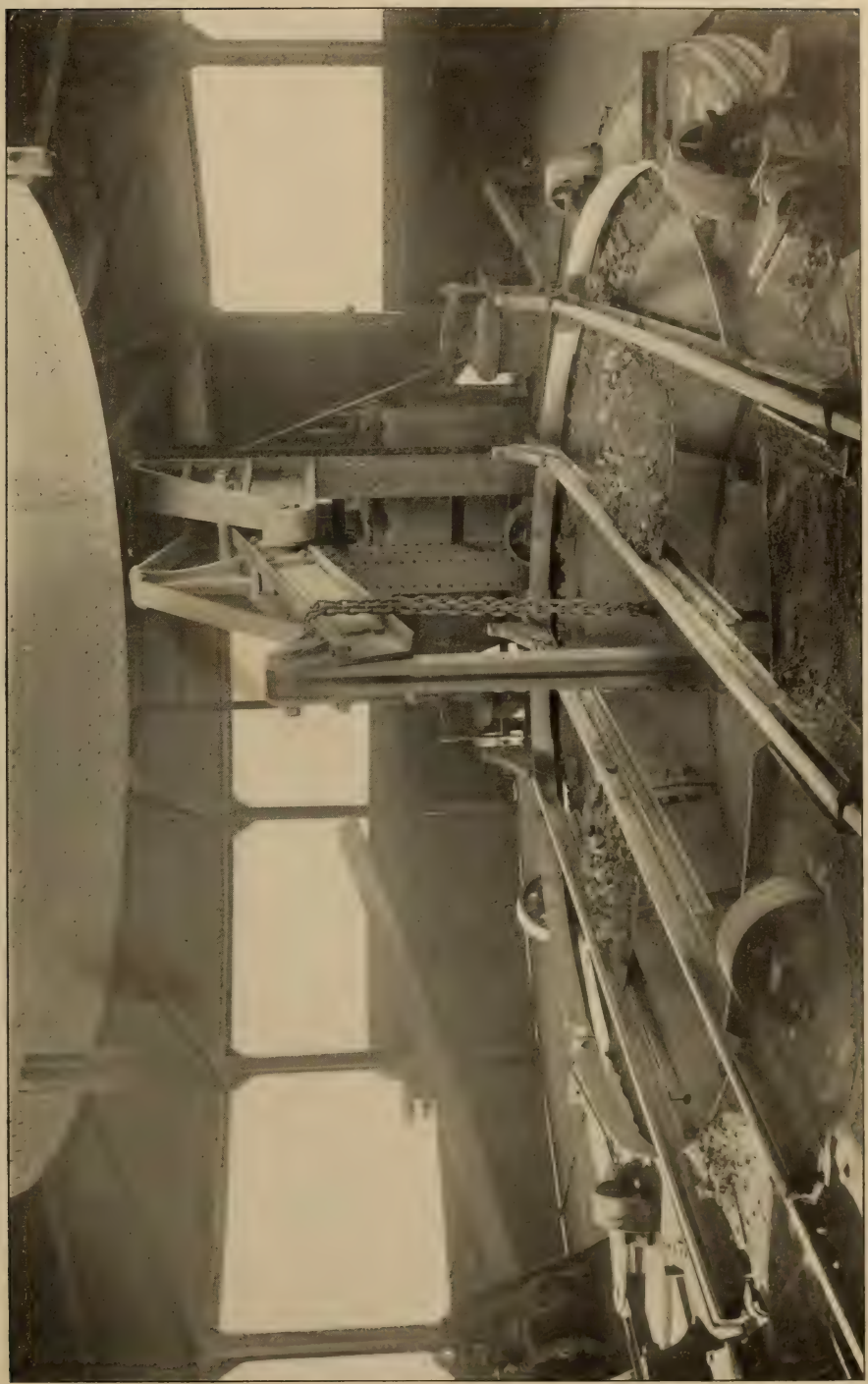


THE BLAST FURNACES AT SPARROW'S POINT



AT THE TOP OF ONE OF THE FURNACES

IN THE BESSEMER DEPARTMENT

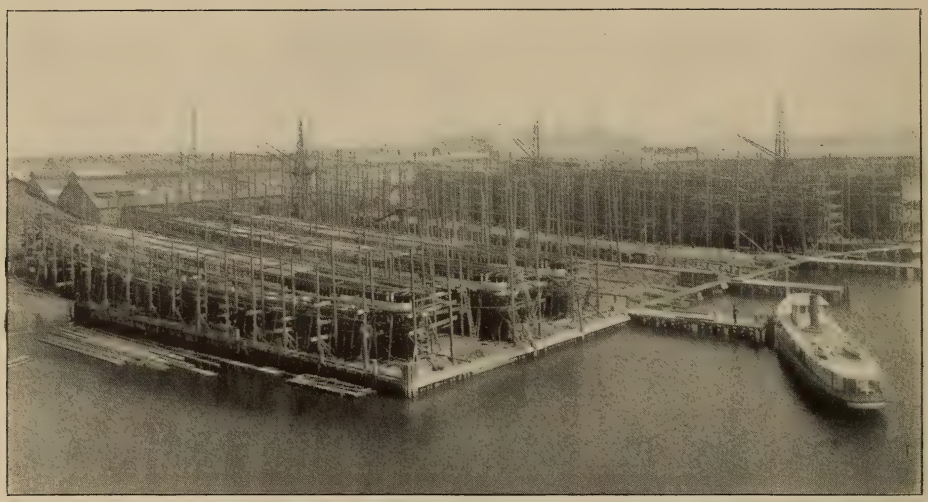
THE RAILS ARE LOADED ON CARS BY A MECHANICAL LOADER, AND HAULED FROM THE YARD BY AN ELECTRIC LOCOMOTIVE

Most iron and steel works are better situated, some adjacent to ore and limestone deposits as well as to fuel, while others have not only water routes, but several railways entering their premises, yet the enterprise at Sparrow's Point has expanded into one of the most notable in America.

Steel furnishes an important part of its output. For several years past the 400,000 tons of rails into which the yearly output of the Bessemer department is converted, have been sold for railways, not only in America but in the Old World as well. Long stretches of the Trans-Siberian Railway have been laid with them, as well as lines in Central and South America, the West Indies, Australia, South and East Africa and British India, and even in the heart of London, rails from the Maryland works have been laid down, forming a part of its underground system.

It might be interesting to dwell upon the importance of this single rail mill in the expansion of trade and civilization, but it is only one result of the general activity. The slag from the blast furnaces has created a cement industry which represents over 100,000 barrels annually. The coke used is now made in ovens on the grounds, which yield 1000 tons daily in addition to such bi-products as tar, sulphate of ammonia, and enough illuminating gas to supply half the population of the nearby city of Baltimore, which has 650,000 inhabitants.

All of these industries are confined to but a portion of the square mile which forms the site of the entire works, for a considerable part of it is occupied by a shipyard and dockyard. While marine construction is merely another outgrowth of the business at Sparrow's Point, it has expanded until from it have come probably more types of craft than have been built at any other shipyard in the world, for not only have ocean steamships been constructed, but sidewheel and propeller steamboats for coast and inland waters, torpedo boat destroyers, passenger ferryboats for rivers and harbours, car ferries, dredges for deep-sea and shallow water, as well as steam yachts and tow boats. The marine department is separate from the dock department, where the two largest



A BIRD'S-EYE VIEW OF THE SHIPYARD

dry docks yet constructed for the United States have been completed.

Aside from the marine work, the resources of the plant have been called into service to build such structures as the lock gates for the ship canal on the Columbia River at The Dalles, Oregon. These gates are the most massive ever planned for such a purpose, owing to the great variation in water pressure which they are required to withstand by the floods in the Columbia River at the point where they have been installed. Several types of steel bridges have also been built at the plant, aside from gun carriages and many different types of marine engine.

It is a question if anywhere in the world steel in commercial form is produced in a shorter period than at Sparrow's Point. The four blast furnaces, the first portion of the works to be erected, have been in service for about fifteen years. Each fur-

TORPEDO BOAT DESTROYERS APPROACHING COMPLETION

nace can turn out from 350 to 400 tons of iron every twenty-four hours. The nearby stock house is 1150 feet long, has a capacity of about 100,000 tons, and is on the water front, as all of the ore is received by vessel.

The Bessemer mill is provided with three 18-ton converters, served by electric cranes. The steel ingots transferred to the blooming mill weigh about 1½ tons each. The ingot moulds are hauled by electric locomotives to the blooming department. There strippers, operated by hydraulic power, remove the moulds and the ingots are placed in soaking pits heated with producer gas. The blooming rolls reduce the ingot from its original size into a bloom 9 feet long and about 4 inches square. All of the shearing is done by hydraulic shears, the bloom being then conveyed to the rail mill, which is practically an extension of the blooming department. The rail mill is equipped with three sets of rolls, and is of sufficient capacity to complete a rail from a bloom in about 15 minutes; this includes the rolling, straightening, sawing, and transferring to the rail yard outside. Probably more sizes of rail for steam

THE 125-TON SHEARS FOR HANDLING MARINE EQUIPMENT

ONE OF THE NEW YORK HARBOUR DREDGING FLEET

A COASTING STEAMSHIP BUILT AT SPARROW'S POINT

railway systems are turned out at this plant than at any other in the world, the weights ranging from 50 to 115 pounds to the yard.

The rails are loaded entirely by electric power. They are pushed upon an endless conveyor provided with "fingers" which can be adjusted to the height of the car platform. When the rail is carried to the top of the incline formed by the conveyor, it slides down and is pushed into place with rail clippers. Frequently, vessels can be seen discharging cargoes of ore upon one side of the wharf, while at the other side are steamships taking on the finished product into which the ore enters.

In spite of the variety of mariner work turned out at this plant, none of the steel manufactured there is utilized in the construction of ship frames or hull plates. All such material is brought from elsewhere, yet steamships having a displacement of nearly 20,000 tons have been built and equipped at the Sparrow's Point

yard. These include several freight and passenger carriers between Great Britain and America. The first American tramp steamship to be completely built and equipped in a shipyard in the United States was also finished there. This vessel marked a new era of American commerce on the Pacific Ocean, and later became one of a line of ships all of which were built at the same yard. With the exception of two vessels, the larger ones of this fleet are of the greatest tonnage plying across the Pacific. They include the "Shamut" and "Tremont," each of 17,000 tons displacement. In fact, this single plant has built the largest group of exclusive freight carriers on the Pacific Coast.

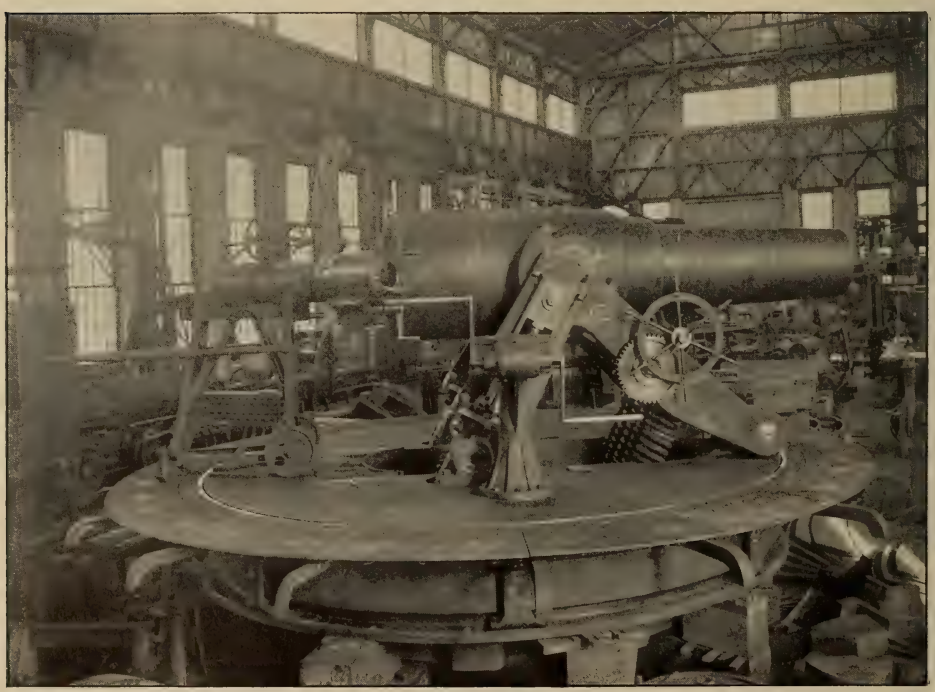
The main ship channel leading into New York Harbour is being excavated to a depth of 40 feet at low tide, by a fleet of dredges all of which were constructed at this yard. In excavating the ship channel, the problem to be solved was how to remove the material in the most economical manner and in the shortest time practicable, as well as to deposit it where it would not form an obstacle to navigation. The employment of the ordinary dipper or bucket dredge, dumping into scows, was decided to be too expensive and too slow a system. The long distance to which the debris must be carried made the use of pipe lines for conveying it to dumping grounds impracticable. The possibility of the dredges being sunk or damaged by heavy seas owing to their exposed position, also had to be taken into consideration.

Two sea-going suction dredges were therefore ordered to be built. They are similar to each other in capacity and dimensions, being 300 feet long, with 52½ feet beam, and draw 22½ feet of water when loaded. Each is provided with a suction pipe, the lower end of which terminates in a series of heads with 8-inch openings, through which the sand and mud are taken. Suction is provided by a centrifugal pump operated by two tandem compound engines.

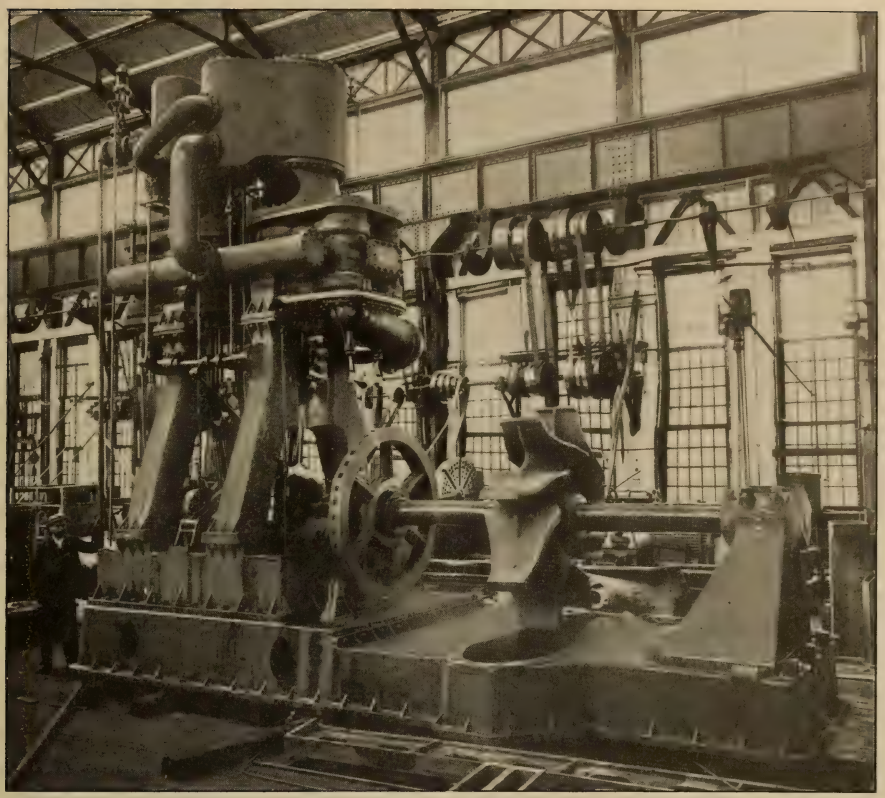
The suction tube is suspended in a well in the center of the dredge, into which it can be raised when out of service. The material as it is taken through the pipe is conveyed

STEAM YACHT BUILT FOR MRS. ANDREW CARNEGIE

TYPE OF HORIZONTAL ENGINE BUILT BY THE MARYLAND STEEL COMPANY, FURTHER ILLUSTRATING THAT COMPANY'S WIDE RANGE OF OUTPUT



CARRIAGES BUILT FOR SOME COAST DEFENSE MORTARS



A DREDGING PUMP ENGINE

into a series of hoppers so arranged that a large proportion of the water taken aboard passes off through the scuppers and is not discharged into the hoppers. The capacity of this type of dredge ranges between 20,000 and 25,000 cubic yards per working day.

Two other dredges which have been added to the fleet of excavators, are of even greater capacity and contain a number of notable improvements designed by engineers in the shipyards. They are named "Manhattan" and "Atlantic," and are similar in dimensions and other respects, being 288 feet long over all, 274 feet between perpendiculars, with 47½ feet beam, and 25 feet depth of hull. When light, they draw only 9½ feet of water, and consequently can be navigated in shallow water. When loaded to their greatest capacity, they draw 2½ feet less than the other type of dredge, even though of much greater capacity.

In ordinary operation, the dredges are moved at moderate speed over the spot to be deepened, the suction pipes dragging along the bottom. Thus the excavation is not confined to one spot, but the bottom of the channel is cut away in furrows, the material being removed to a uniform depth in the distance covered by the suction heads.

The suction apparatus is installed in duplicate, consisting of two 20-inch centrifugal pumps operated by 800-H. P. engines. The material passes through the pipes at the rate of 95 cubic yards of water a minute, giving the dredges a capacity of nearly 60,000 cubic yards in a working day of ten hours. Each dredge contains two hoppers, which com-

A GENERAL VIEW OF THE FLOATING DRY DOCK BUILT FOR SERVICE IN THE PHILIPPINES

bined will hold 4800 cubic yards.

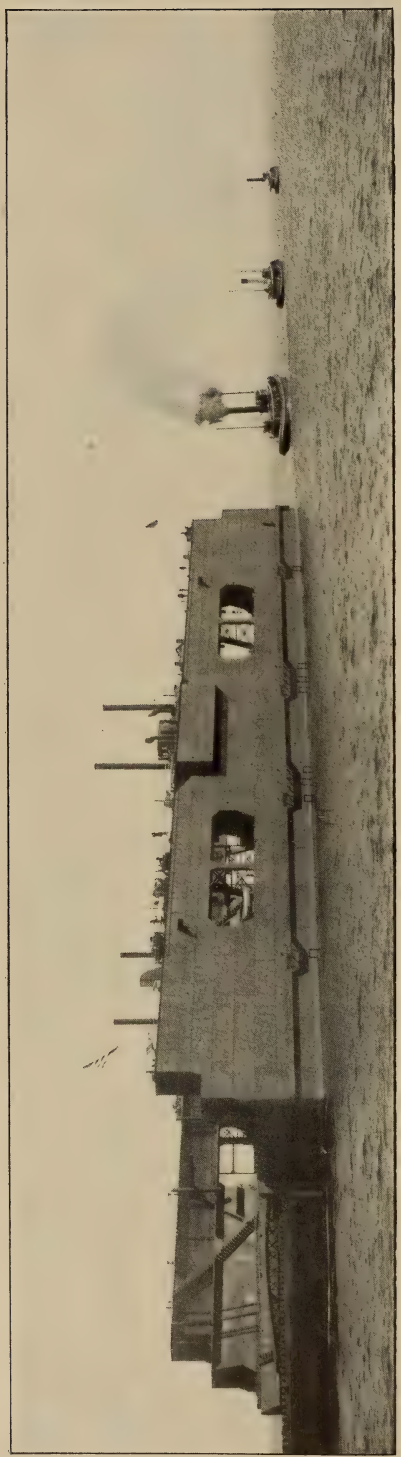
Here also was constructed the "Beta,"—one of the famous "Greek letter" dredges which attracted much attention among engineers. At the time it went into commission the "Beta" was by far the most powerful suction dredge employed anywhere on inland waters, and for several years had the greatest capacity of any of the suction machines on the Mississippi. It consists of two dredges inclosed in one hull, each being provided with its individual pump, conduits, and other connections so that one section of the dredge can be operated independently of the other. The hull is built of steel and is 172 feet long, 40 feet wide, and has a varying depth from about 7 to 11 feet.

The outfit includes two triple-expansion pump engines having cylinders of $20\frac{1}{2}$, 33, and 38-inch diameters, respectively, with 24-inch stroke, the engines being provided with jet condensers. The pumps are located amidships, each having a runner of 7 feet in diameter with a shaft of 10 inches diameter. The discharge pipe is 33 inches, and the suction pipe $33\frac{3}{4}$ inches in diameter. Each suction pipe is provided with three heads, each $19\frac{1}{2}$ inches in diameter. At the ends of the suction pipes are placed cylindrical cutters 5 feet in diameter, which have a speed of 25 revolutions per minute. These are operated by a separate engine placed on the bow of the dredge. The pumps are driven at the rate of 125 to 130 revolutions per minute and discharge through a steel conduit ranging from 1000 to 1200 feet in length. Considering the dimensions of the suction and discharge pipes, and the great power of the pumping engines, it was expected that the dredge would be capable of removing a much greater quantity of material than had any other type of river excavator employed in America. Tests showed that its capacity had been underestimated rather than overestimated, for on ordinary work the "Beta" has removed 5000 cubic yards of sand in a single hour, discharging it at a distance of at least 1000 feet from the point of excavation.

Two notable types of floating docks have been built at the Sparrow's Point works,—the one for service at Algiers, on the Mississippi River, and the other a self-docking dock intended for use in the Philippines. The latter was recently completed and is at present being towed to its destination. The dimensions of the latter are,—Length, 525 feet; width, outside measurements, 134 feet; width between the inner walls, 100 feet. Its maximum depth in the water is a few inches less than 63 feet, while the length of the side walls is nearly 500 feet. Without its machinery and other equipment, the hull weighs over 6000 tons, the machinery adding 1000 tons.

The sheathing of the dock consists of steel plates fastened to a steel framework. There are three center pontoons secured to the side walls by two horizontal rows of fastenings. The pontoons differ in size and form. The center one is 240 feet long and rectangular in shape, but the two terminal pontoons have parallel sides for about 80 feet of their length, the remainder being finished off in the form of a blunt bow. For a length of 110 feet these end pontoons are buoyant, and the remaining length, forming the point proper, is formed by a series of plate and lattice girders of strong construction.

The specifications require that a vessel may be docked in $3\frac{1}{2}$ hours from the time she enters. This includes the mooring, pumping, and lifting operations. The pumping machinery is located in the side walls. The pumps are horizontal, with branch pipes leading through all the different watertight compartments. Each pair of pumps is driven by a vertical compound engine of 225 H. P., located in the central and upper portions of the side wall. The steam pipes are arranged so that an



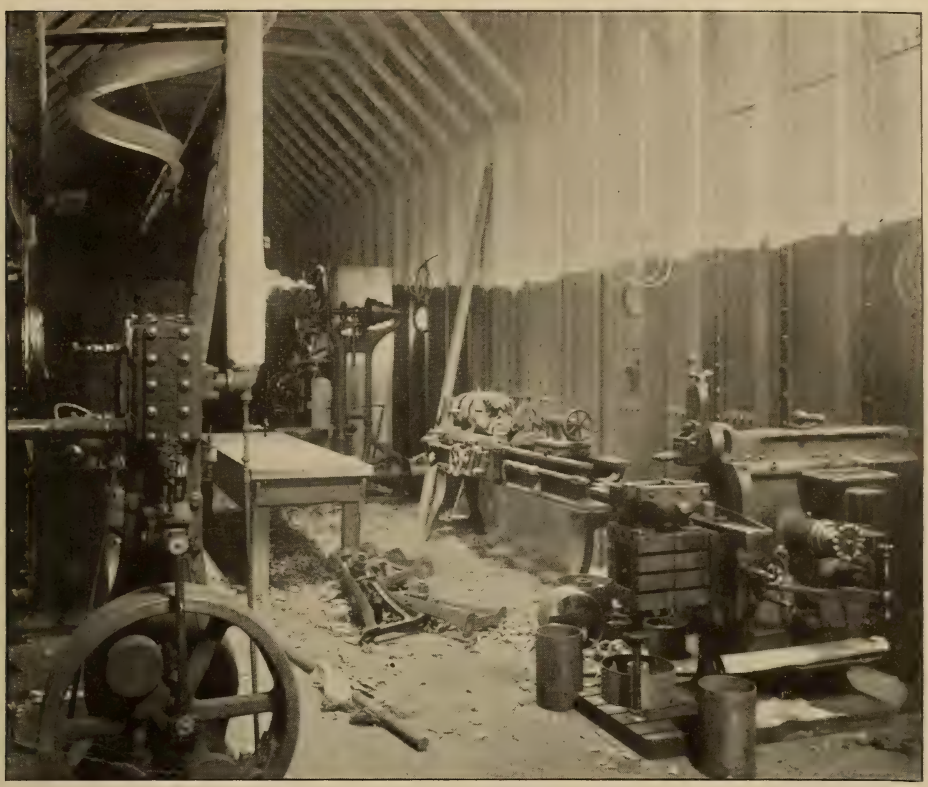
THE ALGIERS DRY DOCK ON ITS WAY TO THE MISSISSIPPI RIVER

engine can take steam from any boiler, and if only one boiler, engine, and pump remain at work, the whole dock can still be lifted. A complete "washing-down" service is installed in each wall, worked by independent pumps.

The whole dock is operated from two central positions, one on each side wall. In the valve houses are grouped signal levers, by means of which all the different valves can be operated. Each valve house is in direct communication with the engine house by means of speaking tubes, so that the dockmaster can control every water valve and steam valve for maneuvering the dock, without leaving his station. The "Dewey," as the great dock is called, has also a machine shop equipped with everything necessary to make simple repairs to a vessel, as well as to supply extra parts. There are quarters for a crew of nine officers and twelve men, and even a kitchen and a library have been provided in the great side walls.

After completion, the dock was anchored in Chesapeake Bay. There the cruiser "Colorado," of 13,350 tons displacement, was docked with entire success, being lifted to a free-board of $2\frac{1}{2}$ feet above the surface in less than three hours. Following the cruiser test, the battleship "Iowa," of 11,600 tons displacement, was lifted to a height of $4\frac{1}{2}$ feet above the surface. Although of less tonnage, the "Iowa" is so much shorter that her weight was distributed over a much smaller portion of the structure; yet the strain, as shown by the deflection of the keel line of the dock, was so slight as to prove that the dock can lift a ship of 20,000 tons displacement without endangering its frame.

Only a few instances of the creative work which has given the little industrial center of Sparrow's Point such a wide reputation have been mentioned here, but in describing the activity at the place as an illustration of how a single industry can



THE MACHINE SHOP ANNEX TO THE PHILIPPINE DOCK SHOWN ON PAGE 366

expand into a group of industries, each of important proportions, created in a limited area, it is interesting to bear in mind that all this is accomplished within a relatively restricted area, quite unlike the conditions found in many other manufacturing enterprises of similar extent. At the great Krupp works, in Germany, for example, each division forms a city in itself. The smelting of the ore is done at such places as Rheinhausen, which is many miles from Essen, where, in the form of steel, the original product of the blast furnaces enters into the making of ordnance, armour plate, and railway material. Every ton of ship plates used at the Krupp Germania yards at Kiel comes from iron smelted at a distance.

At the Sparrow's Point works the rails emerge from a mill situated within half a mile of where the ore is reduced. From end to end, the Sparrow's Point works are less than a mile long, and but 700 acres are occupied by the several industries, including the homes of the operatives, the offices of the company, and the various storehouses. The works as a whole exemplify concentration and centralization in a pronounced degree.

WAGES AND PROFITS IN THE BRITISH COAL TRADE

By T. Good

IT is questionable whether there is any trade or industry about which so many fallacies exist in the public mind, as the coal trade. From time to time we are presented on the one hand with graphic pictures of miners delving at a hazardous and unhealthy task for a mere pittance of 3s. or 4s. per day,—raising a ton of coal with infinite toil and danger for but a fraction of its selling price (for as little as 8d. according to one well-known writer), and of colliery proprietors and coal merchants driven to the verge of ruin by the imposition of a tax of 1s. per ton on coal for export; whilst on the other hand we have glowing accounts of miners with £3 to £4 per week for about four or five days' work of about 6 or 7 hours, and of colliery owners growing rich beyond the dreams of avarice.

Each of these allegations may possess a modicum of truth so far as they relate to individual and isolated cases, but they supply no evidence upon which to base a calculation, even approximately correct, concerning the relationship between wages and profits on the average,—upon the relative rewards to capital and to labour in this important industry.

To get at the exact truth concerning wages and profits in the coal trade is, of course, impossible; but from such facts and figures as are within reach of any close student of affairs, it is not difficult to get near enough to the mark for all purposes of public interest.

There were drawn during the year 1904 in the United Kingdom 232,428,272 tons of coal; this output provided employment in hewing, timbering, drawing, and in putting into trucks, etc., for as nearly as can be made out, 772,000 men and boys. This represents an output for the year of about 300 tons per person employed in and about these coal mines. One writer states that the average annual output of coal in Great Britain, spread over a period of years, has been only 275 tons per man and boy, against an output of 526 tons in the United States. But in passing it is only fair to mention that in America natural conditions are somewhat more favourable than in Great Britain, and also that there are fully 7000 coal-cutting machines at work in the former country against a very few hundreds in Britain.

However, to come to the point at issue, the pit-mouth value of the 232,428,272 tons of coal raised in Great Britain in 1904 amounted to £83,851,784, giving an average price per ton of 7s. 2.58d. Now, suppose the 772,000 coal mine workers averaged only £1 per week each in wages in 1904, the cost of labour would have been £40,144,000, or an average cost of slightly over 3s. 5¼d. per ton. But the cost of the labour employed must have been considerably more than this amount, which is actually

less than half the selling, or rather pit-mouth, price of the product.

According to Board of Trade Returns, two-thirds of the average pit-mouth price of coal go in wages alone. For a period of 15 years (1886-1900) we have the following figures:—Tons drawn, 2,802,395,000; value at pit-mouth, £953,477,000, or an average of 6s. 9.65d. per ton; paid in wages, £642,386,000, which gives an average cost of labour of 4s. 7.01d. per ton.

Now, suppose that two-thirds of the pit-mouth price of coal went in wages in 1904,—say 4s. 10d. out of the 7s. 2½d., which was about the average price per ton,—that would represent a sum of nearly £56,000,000. That sum, equally divided, would have given the coal mine workers an average weekly wage, the year round, of 27s. 9d. per man and boy. But to give the miners the benefit of the doubt, to avoid exaggeration, and to allow for the alleged recent reductions of miners' allowances, we will put the cost of coal-mining labour at 4s. 6d. per ton, making a total wages' bill of £52,296,361 for the year, or an average weekly wage of 26s. per man and boy employed.

From this we may reasonably contend, therefore, despite our natural sympathy for the underground worker, that in consideration of the general and much-to-be-regretted industrial depression prevailing throughout the country during 1904, of the frequent periods of unemployment suffered by workers in industries other than coal mining, of the short hours worked by miners, and of the fact that their trade is by no means a highly skilled one requiring a tedious apprenticeship, miners were not, and are not, a poorly paid class of workers.

Moreover, when all is said that can be said truthfully, the work of the coal miner is not exceptionally unhealthy, for despite his liability to accidents which shorten, when they do not destroy, life, the miner stands twenty-third in a total of fifty different classes of workers in the comparative mortality tables; whilst if we exclude deaths from accidents, to quote Dr. Ogle, "the mortality of coal miners only slightly exceeds that of the most healthy class of men in our tables."

Coming now to the question of profits. The Board of Trade and Inland Revenue Returns for a period of 21 years (1880-1900) give us an average of about 2s. 2d. per ton to provide for lease fees, rents, royalties, wayleaves, etc., cost of plant, materials of all kinds except coal used on the plant, general expenses except wages, and the profits. As clear profit on mining, Board of Trade Returns give on the average 6d. per ton for 15 years (1886-1900), and Inland Revenue Returns give 5½d.

From another calculation based on Inland Revenue Returns for a period of 21 years (1800-1900), we find that the average amount per ton divided between coal lessors and lessees, that is between the landlords, or royalty owners, and the colliery proprietors, was 11½d.. The Royal Commission on Mining Royalties estimated that in the year 1889 the lessors' share of this 11½d. was just one-half, or 5¾d. in the shape of rent, royalty, etc., leaving, therefore, another 5¾d. for the colliery owners,—an estimate not differing materially from the other calculations just given.

If we allow, then, that in 1904 labour received only 4s. 6d. out of the 7s. 2½d., which was within a fraction of the average pit-mouth price of coal, we are left with but 2s. 8½d. to meet cost of rents and royalties, of materials such as timber, horses, food, oil, etc., of management expenses, and of dividend on capital invested. How much of this 2s. 8½d. represented clear profit?

J. H. Merivale, an authority upon mining matters, says that the cost of the various materials used in coal mining averages about 7½d. per ton of coal raised, and that salaries, sales' commissions, local rates, compensa-

tion, and sundry expenses amount to another 6½d., making 1s. 2d. This leaves us with 1s. 6½d. to account for.

It may not be out of place here to mention briefly the burdens which have been placed on mining by legislation in the interests of the workers. Whilst it is only right that every endeavour should be made by legislative enactment, as well as by voluntary effort, towards improving the health and increasing the safety of the workers, it is just as advisable to note the increased cost of production resulting from State regulation of industry, especially in these days of socialistic demands. Mines acts and mines amendment acts, employers' liability acts, and workmen's compensation acts, have followed one another in fairly rapid and regular succession, and have invariably increased the cost of production.

It was given in evidence before the Royal Commission on Trade Depression that the Mines Act of 1872 increased the cost of coal production by 8d. per ton. It was also computed that the Mines Act of 1887 added 3d. per ton to the cost of production. An eminent colliery proprietor, Earl Granville, in a speech in the House of Lords, put the increased cost of production by legislation at from 1s. to 2s. per ton, according to various circumstances and conditions prevailing at different mines; whilst C. M. Percy, of Wigan, an authority on mining affairs, put the increased cost through the various acts passed from 1872 to 1887, inclusive, at not less than 1s. per ton. Since then other acts have been passed, and local rates have also gone up.

However, to return to the point under discussion, how are we to apportion the 1s. 6½d. which we have found would be about the amount per ton divided between coal lessors and lessees during 1904? In this connection the cardinal question and the most debatable one is:—What would royalties amount to? As already mentioned, the Royal Commission on Mining Royalties estimated them to average 5¾d. per ton in 1889. Since then coal prices have advanced, up to 1904, by 10½d. per ton, and as royalty rents are in many cases fixed on the "sliding scale" principle, it is safe to say that during 1904, on the calculation just referred to, royalties would average 7d. per ton.

But the Royal Commission admitted that the information upon which they based their estimate was "meagre," whilst there is ample evidence to support the idea that the total royalty charges of all kinds,—including lease fees, rents, royalty per ton of output, wayleaves, waterleaves, airleaves, etc., several of which items the Commission took little note of,—average very much more than the sum just named.

D. A. Thomas, M. P., says that royalties upon Welsh coal that has been leased, or on which the leases have been renewed, during the last few years, have gone up by "several pence per ton"; whilst another authority upon mining royalties who has gone very fully into the matter, asserts that the total amount of royalties, etc., upon coal in Great Britain is not less than 1s. per ton on the average.

All this evidence supports the contention that profits on coal mining in Great Britain, spread over a period of, say, 31 years, which is about the average length of a coal mining lease, amount to not more than 6d. per ton. What does this mean in the shape of dividend on capital invested in this industry? As near as can be made out, the capital invested in British coal mining is 10s. per ton of output, or roughly, £116,000,000. This means a gross dividend of 5 per cent. per annum, but allowing for redemption of capital at 3 per cent. over a period of about 31 years, 2 per cent. of the 5 are absorbed; this leaves but 3 per cent., or £3,480,000 per annum, as net profit, or rather dividend, on the capital invested in an industry yielding over £52,000,000 a year in wages.

BOILER-HOUSE ECONOMY

By Alfred W. Bennis, M. I. Mech. E.

IT is almost impossible to overestimate the importance of the fact that of the factory or works cost of the manufacture of salable product, whatever this may be, the fuel bill represents about 50 per cent. The fact that a cheap class of fuel can be used is no reason why it should be wasted; yet it is because of such waste that lack of economical results prevails in so many boiler houses.

In the past, at engineering colleges and universities it has not been the practice always to consider every engineering job from the standpoint of the commercial engineer. One must consider not only what is the best job, but what is the best with regard to first cost, up-keep, and cost of running.

Suppose, for example, a draughtsman gets out a couple of schemes for a factory plant. Is he ever asked, not which is the best, but which is the cheapest way to do the work without sacrificing efficiency? How much power will it take to run the factory laid out on the different plans? Which plan will require least repairs and is the most get-at-able?

We feel that this point of view of engineering cannot too strongly be impressed upon the minds of the engineers who are now growing up.

Mr. Geldard, F. C. S., in a paper read before the Bradford Engineering Society on "Economy in Steam Raising," gave it as his opinion that engineers and power users have been "too prone to give all their attention to the question of engines," and he adds, "we thus see in many places splendid engines which are very economical in steam consumption, and yet badly designed, badly worked, steam-raising plants. Mill owners have been willing to spend thousands of pounds on engines, and yet have grudged the expense of a few hundreds to increase the economy of the boilers."

Steam engineers appear to have come almost to a full-stop in effecting economies in the engine house, but there is plenty of room for improvement in the boiler house. Henry Willock Ravenshaw, in a recent Cantor lecture before the Society of Arts, said:—

"With regard to coal consumption it must be remembered that although coal may be cheap, boilers cost money to put down and maintain. We have gone rather thoroughly into this question, and we find that, on an average, for every ton of coal burnt the costs for labour, boiler repairs, depreciation and interest on capital, amount to at least 2s. 6d.; consequently, even if the coal cost nothing, a ton saved per day would mean a saving of at least £40 per annum. In large collieries from 50 to 80 tons a day are burnt under the boilers, and in many cases it is practically certain that this consumption could be reduced by one-half."

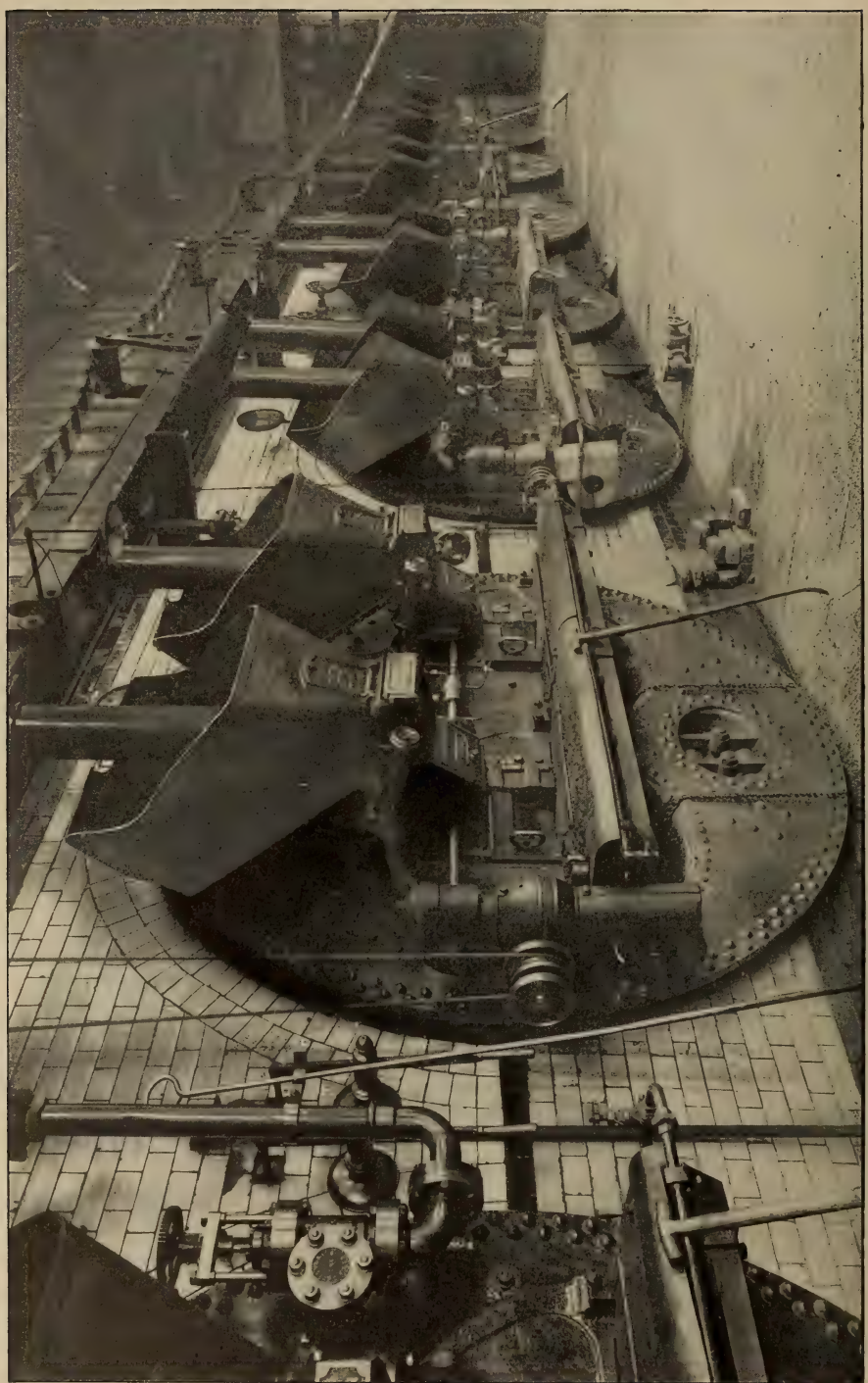
Some of the points requiring careful attention and where unnoticed losses may creep in, are:—

1.—Badly designed flues or chimney, causing poor draught. In cases of this kind the chimney has been known to take 25 per cent. of the coal to keep up its draught.

2.—Leaky brickwork in flues or chimney.

3.—Paying too much for coal, through not knowing its calorific value.

4.—Low temperature combustion



A VIEW OF THE BOILER-HOUSE OF MESSRS. MARTIN, SONS & CO., LTD., HUDDERSFIELD, ENGLAND, EQUIPPED WITH MECHANICAL STOKERS AND COAL-HANDLING PLANT BY MESSRS. ED. BENNIS & CO., LTD., BOLTON

and consequent inefficient heat transmission.

5.—Using a high-pressure boiler for low-pressure work.

6.—Avoidable radiation losses through more boilers being in service than are necessary.

7.—Inefficiency, or lack of boiler, steam, and feed-water pipe covering. A reasonable return can be made even if it costs 1s. 0d. per square foot for covering. Experiments have shown that each square foot of uncovered steam or boiler surface wastes on an average 10 cwts. of coal per annum.

8.—The excess of air necessary in low-temperature firing to keep down smoke.

9.—Reducing the air supply too much through misinterpretation of the data furnished by gas analysis apparatus.

10.—The want of enough heating surface in economizers.

11.—High terminal gas temperatures due to prolonged combustion in hand and other inefficient furnaces.

12.—Scaly and dirty boilers, economizers, etc.

13.—No spare boiler, no time to clean, etc.

14.—Leaky steam traps. Arrangements should be made so that the outlet is always visible. Leakage can then be rectified at once.

15.—Wasteful pump and auxiliary plant.

16.—Coal and ash handling costs too high.

SOME REMEDIES FOR INEFFICIENT PLANT—THE CHIMNEY

Let us consider the chimney end first, as if this is wrong everything else will be so too. For every boiler of the Lancashire type of from 8 to 9 feet diameter we need an area of 6 square feet in the chimney up to four boilers; after that we want 5 square feet for every additional boiler. The height of the chimney should not be less than 120 feet, and, unless there are special reasons for it, not more than 180 feet. But the entrance to this chimney must also be considered. The draught has to turn up in the chimney, and therefore there is an obstruction here for which provision must be made by enlarging the entrance so that if the chimney itself has, say, four boilers calling for 24 square feet, and two more boilers calling for 10 square feet extra, making a total area of 34 square feet for six 8-foot boilers, the chimney entrance should be at least 40 square feet in area, that is, roughly, 10 per cent. more than the boilers alone call for.

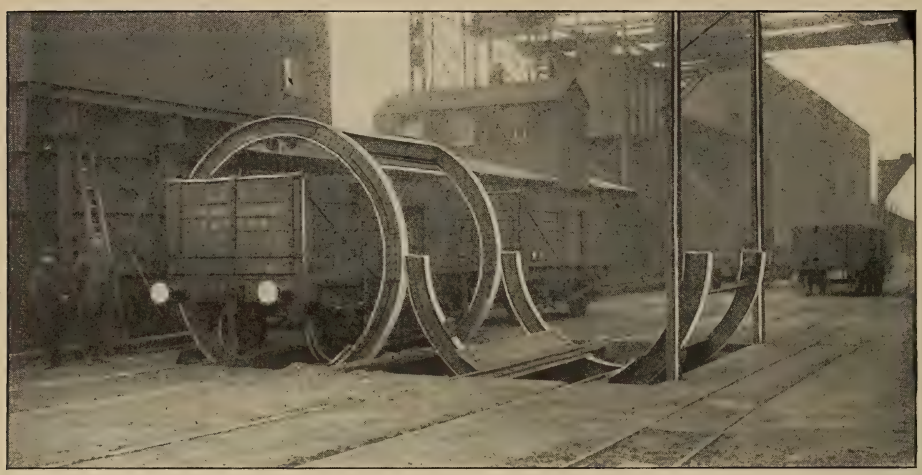
If the chimney has a straight entrance, it is easily seen that a portion of the chimney effect is lost, as the draught, having a considerable velocity, will push the air out and go a foot or so from the entrance before it turns up; therefore the last foot or two of the entrance to the chimney should be at an angle of 45 degrees upwards. It is not necessary to make this round, as it will give a better result to have it at the angle stated.

We have now provided for a chimney and entrance—a chimney that will give us the highest result possible. It is safe to say that 90 per cent. of the chimneys erected are wrongly constructed in this particular.

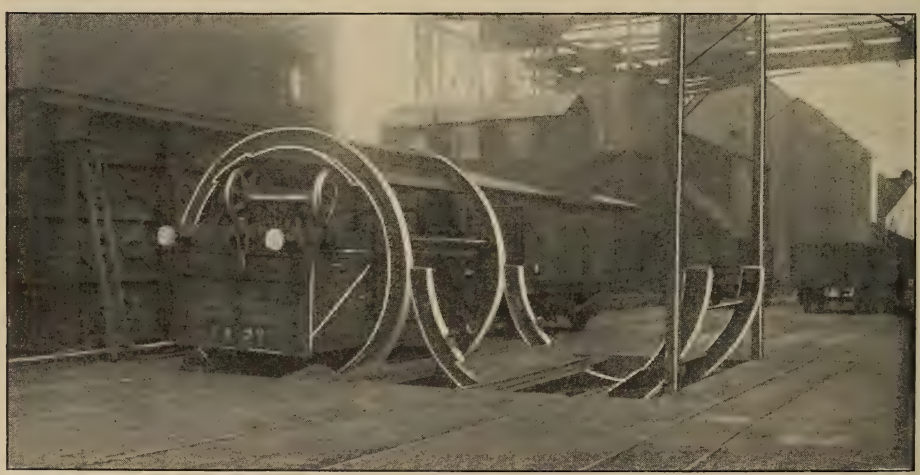
The next point to be considered is the flue to the economizer, the economizer being the part of the flue system always at work, continuously in service except for cleaning, repairs, or some such reason. The greatest pains should therefore be taken to have this of the best possible character, and if there is any advantage to be given, give it to the economizer.

The area of the flue to the chimney from the economizer must be as great as that of the chimney itself, but not as large as the entrance to the chimney, and if there can be a slight gradual rise all the way to the chimney it is a great advantage.

The size of the economizer being settled, we have to take into account the area between the pipes. The flue under consideration having an area



A REVOLVING CAR TIPPLER AT THE WILLESDEN METROPOLITAN ELECTRIC SUPPLY COMPANY'S STATION



HERE THE TRUCK IS SHOWN REVERSED

of 34 square feet, we want 40 square feet in the economizer. This will probably be attained quite easily, as if we have a width of eight pipes, and 3 inches between each of these pipes, there will be 20 square feet here, and by keeping the side doors of the economizer open, we shall gain the other 20 square feet. This is not as desirable a plan as can be devised, but it is much better than cramping the draught in a vain attempt to squeeze it through the tubes.

Of course if the economizer can be made wider, so much the better, but, as a rule, the draught is cramped and partially spoiled in existing economizers, and therefore the results of firing are worse than they otherwise would be.

Although it might be supposed to be outside the scope of this paper, a few words upon the building of the brick wall of the economizer which faces the open air may be of use,—that is, the wall usually farthest away from the main flue. This is generally built as if it were the wall of

a house, though it has an entirely different purpose to serve. It ought to be 14 inches thick, but whether 1 inch or 9 inches, it should be bonded at every row, and the bricks should be covered all over with mortar, not dabbed on as in ordinary building, and as is usual in installing an economizer.

It is a bricklayer's fallacy to suppose that cracks result from covering the bricks all over with mortar. If the covering be properly done on all sides of the bricks, a much more lasting flue is built, and we do not find, at the end of a year or two, if we put a lamp flame near the economizer, that it is drawing at every pore. Flues built on this principle under our supervision did not require repairing after ten years, and there were no leaks, but in this case care was taken that there was not too much mortar,—that is, that the bricklayer did not leave $\frac{3}{4}$ inch or so of mortar between each layer of brick, which may be the easiest way of building, but not the best way for permanency. The 5 per cent. extra cost of building in this way has been paid for fifty times over by the fact that subsequent attention to this part of the work has been unnecessary, no repairs being called for during a very long period.

Passing now to the flue behind the boilers, leading into the economizer, the usual plan is to make a straight flue which ends in the economizer, and, however many boilers there are, not to enlarge it at all, but to have it as large at one end as at the other. The proper way is, at the end away from the economizer to make the flue at least 1 to 2 feet lower in the roof than at the end next to the economizer, so that as the gases are increased in volume as they pass boiler after boiler, they will roll with increased velocity towards the economizer.

TAKING COAL FROM A BARGE INTO A BOILER-HOUSE WITH A BENNIS ELEVATOR AND INCLINED CONVEYOR

We shall at once be met by the objection that if it is requisite to have to pass the other way to the chimney when the economizer is stopped, this design cannot give as good a result

as if the flue were full size. As a matter of fact, supposing the flue for the six boilers to be 36 square feet as it ought to be, that is, somewhat larger than it is farther on, and that it is 5 feet wide and 7 feet 2 inches deep, then if it begins at 6 feet at the farthest end from the economizer and ends at 7 feet 2 inches, the draught will be as nearly as possible the same, whether taken through the economizer, or taken direct to the chimney without the frictional resistance offered to the flue gases by the economizer. Of course, when working without the economizer this will not be quite so good, as the work of the economizer is lost and the draught is not better; but one would not spoil the result for 300 days in the year for the purpose of securing equal results during the thirteen days that the economizer may be stopped. These points are frequently overlooked, but they are essentials in getting the best results.

The boiler itself should be set with as wide bottom flues as convenient, and for this reason:—Gases rise to the top and thus adhere to the boiler when they are moving horizontally underneath, but when they get into the side flues they do not adhere in the same way to the boiler, and the heat is not extracted so well.

The sum of the areas of the two side flues of the boilers in the range ought always to be about 100 per cent. more than the flue total behind the boilers, but this is a minimum—about double that allowed for each boiler in the main flue. The reason for this is partly because of the great friction, and because the hot gases in active movement having to force their way into the main flue require more room.

We now come to the boiler house proper, and the appliances for economizing the cost of consuming the coal and preventing smoke. The words used by the late C. Wye Williams, from a book published sixty-four years ago in Liverpool, are as true to-day as when they were written, and this in spite of the fact that the business horizon has been so extended, and that unremitting energies of competitors to undersell each other in the open market are probably as keen at the present time as they have ever been and are ever likely to be. The quotation considered so applicable is here given:—

"It may be asked how has it happened that hitherto the smokeless combustion of fuel has not been effected. I answer because the chemistry of combustion has been neglected, not in the laboratory, but in practice; and because the construction of our furnaces has been too much left to those who know little of the chemical properties of the matters which are consumed in them."

We recommend frequent sampling of the fuel used. It may be laid down in connection with this that the sampling and testing should be carried out by an expert. It has well been asserted, in a paper read before the Institution of Electrical Engineers by Messrs. W. H. Booth and J. B. C. Kershaw, that "a sample of only 1 pound in weight, when properly taken, can be truly representative of 50 to 100 tons of coal; and from such a 1-pound sample a trained chemist can, by further grinding and reductions, obtain a sample of 2 grammes or less, which shall be equally representative of the original bulk of fuel."

What is done with whole shiploads of ore to the interest of both buyer and seller, may also be accomplished in the case of fuel, but the fuel tests must be intelligently conducted and controlled. Men must be specially trained for this special work. It would be a step in the direction of greater boiler-house economy if, when an automatic coal conveying plant is installed in a boiler house or elsewhere, automatic sampling arrangements were made a part of the installation.

It has been said that trained chemists should not off-hand undertake fuel calorimetry, as a certain amount

of practice and experience are necessary before the results are really accurate; but for practical purposes any intelligent man can soon take readings, which are near enough for comparative purposes, or at the lowest estimate a long step in the right direction.

All practical users of fuel know perfectly well that it is not always that which yields the best laboratory test that also yields the most steam per pound when burnt under the boilers; yet this fact should not be used as an argument against fuel analysis and calorimetric tests, nor would it be, were there a better appreciation of the laws of fuel combustion beneath boilers. Laboratory tests, when ably carried out, are of incalculable value when placing fresh contracts for fuel supplies, aiding, as they do, the search and selection of a suitable fuel fitted for burning in any variety of furnace.

At the same time we would say fuel calorimetry is simple enough, and though we would not advocate the placing of large contracts for fuel except from the results obtained by experts, we would have a calorimeter in every boiler-house equipment, and a small sample could be collected each day, averaged at the week-end, tested and logged up on the weekly coal and water record. It would soon be seen whether heat unit value for money was being obtained; and should a doubt arise, a sample, checked by a qualified coal analyst, would turn doubt into certainty.

It will frequently be found that cheap fuels, perhaps rather small, from one colliery, contain nearly, or quite, as much heat as other fuels larger in size and much more expensive, from another, or even from the same colliery.

It makes little or no difference to a high-class mechanical stoker what the size of the fuel may be,—it will burn one as efficiently as the other. The fact that hand-firing cannot do this, enables advantageous coal contracts to be placed by those who possess good machine-stoking plant.

A few examples will demonstrate this. In the first instance may be cited that of the Whalley Bank Mill Co., Blackburn. The rough slack used by hand-firing contained 10,698 B. T. U. per pound, and cost 8s. od. per ton delivered. The fine slack which was not suitable for hand-firing cost only 6s. 9d. per ton, delivered, and had actually 12,070 B. T. U. per pound, the actual reduction in fuel cost per 1000 gallons of water evaporated being 37 per cent., a truly magnificent return upon the original outlay for the stoker and furnace.

In the second case, that of Alexander Carus, of Hoddleston, a mixed coal was used—the machine, however, using a larger proportion of the common coal. Here, again, the advantage, though only a slight one, lay with the so-called inferior fuel, and, with the good thermal efficiency obtained by machine firing, resulted in a reduction in fuel cost per 1000 gallons of water evaporated of 23 per cent.

The third case is, we think, one of the most striking that has come under our notice. Messrs. Bluemell & Bros., of Coventry, had to use best hard steam coal by hand firing in order to maintain their steam pressure. It cost 10s. 6d. per ton, delivered, equal to 246,000 B. T. U. for each penny expended.

Machine firing used smudge costing only 4s. od. per ton, delivered, and while giving more evaporation, obtained 518,000 B. T. U. for each penny, resulting in a reduction in fuel cost per 1000 gallons of no less than 57 per cent.

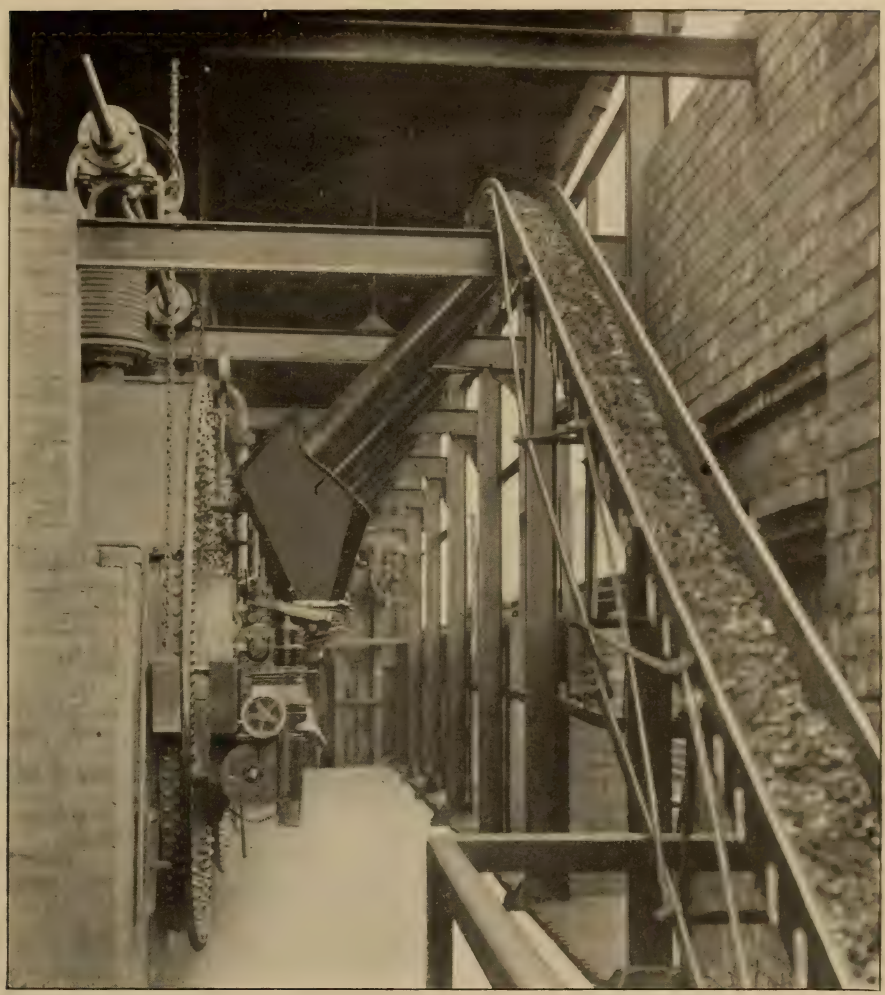
The fourth and last example to which we shall call attention is that of Messrs. Tangyes, Ltd., the engineers of world-wide renown, who have recently applied machine firing to their boilers. It will be noticed that the cheapest fuel is only slightly below the other in calorific value, and, comparing the two machine-fired trials, gained on the other by 2.8 per cent. in fuel cost reduction.

BOILER-HOUSE OF CARLTON MAIN COLLIERY, SHOWING BENNIS MECHANICAL STOKERS AND COMPRESSED AIR FURNACES, AND COAL CHUTES LEADING TO THEM

The same priced fuel as with hand firing, owing to the much greater efficiency of the machines, showed 26 per cent. fuel cost reduction, and the cheaper fuel, 28.8 per cent., as compared with hand firing.

The fact should not be lost sight of that the furnace must be constructed to suit the fuel if high efficiencies are to result. It has in the past been too often the custom, and is too often the custom at the present time, to take the word of the boiler maker as the final one in this matter; yet the whole truth of the matter, and the whole wisdom of a suitable selection, does not rest with any one class, be he representative of boiler makers, stoker makers, or maker of elevating and conveying plant. "In the multitude of counsellors," says the old proverb, "there lacketh not wisdom," and it is, after all, morally certain that wisdom will not die with the boiler makers.

We hold no brief, when considering boiler-house economy, either for shell or water-tube boilers. Each



THE BOILER-HOUSE AT FRICKLEY COLLIERY IS EQUIPPED WITH SIX PAIRS OF BENNIS STOKERS AND COMPRESSED AIR FURNACES. THE COAL IS RAISED BY AN INCLINED CONVEYOR WHICH FEEDS THE CHUTES TO THE STOKERS

has its special advantages, and it is for those responsible for the conduct of any particular boiler house to decide on the type most suitable in an individual instance. It is claimed on the one hand that the shell type of boiler has the advantage of larger water contents and steam space, and is, therefore, when once on load, better adapted to respond to sudden demands within limits. On the other it is claimed that the water-tube boiler possesses greater furnace potentialities, which are easily secured. Yet, in spite of these claims, it is with boilers, as with many other things, a blunder to endeavour to fit a square peg into a round hole; in other words, the shell boilers are, without doubt, better adapted for some boiler houses than the water-tube boilers, and the reverse also holds good.

H. R. Armitage, in a paper read before the Bradford Textile Society, has pointed out that "a boiler plate is capable of transmitting a far greater amount of heat than is gen-

erally presented to it, and the greater the difference of temperature between the two sides of the plate the quicker is the heat transmitted, and consequently the greater is the evaporation." In order to prove his assertion, he offers the following figures:—

	(1) Degs. Fahr.	(2) Degs. Fahr.
Temperature of down-take..	1,179	952
Temperature leaving boiler..	671	566
Temperature, difference.....	508	386
Pounds of water per square foot heating surface per hour	9.01	5.5
B. T. U. transmitted per hour	9,929	6,069

From these figures it is seen that a difference of 217 degrees in the downtake is reduced to 105 degrees, leaving the boiler, or, in other words, 10 per cent. more absorption in the shell of the boiler with the higher temperature gases. The furnace temperature must have shown a much greater difference, and in the furnace tubes the evaporation in the first case must have been very considerably greater.

The number of British thermal units transmitted per minute through a given boiler plate is proportional to the square of the difference in temperature between the gases of combustion and the water, the constant for each thickness of plate varying somewhat.

Mr. Blechynden in a paper on "The Transmission of Heat Through Steel Plates," published in the Proceedings of the Institution of Naval Architects in 1893, shows this by means of a series of ninety-four careful experiments, which, though made twelve years ago, are still regarded as exemplifying standard research in this direction.

The mean value of the series of experiments shows that for a $\frac{3}{4}$-inch steel plate the number of British thermal units transmitted per square foot of heating surface per hour is equal to 0.0177 multiplied by the square of the difference of temperature between the hot gases and water, whereas, for a plate 9-16 inch thick the constant is increased to 0.02119, or practically 20 per cent.

These experiments indicate that the higher the furnace temperature, the greater the efficiency of the transmitting medium,—the boiler plate; the greater the efficiency of the boiler; and the greater the evaporative power. They also show some other things.

If it is decided that you want a new Lancashire boiler you go to a boiler maker and say, perhaps,—"I want an 8 foot 6 inch by 30 foot 0-inch boiler for 120 pounds pressure; that's what my other boilers are working at. What's your price?"

So he says:—"Well now, have you considered that pressures are going up, and that it is possible that in a few years' time you will want to increase your pressure? Hadn't you better let me quote for a boiler to stand, say, 200 pounds—it will be all the safer, and will be there when you want to put up your pressure." So you say, "All right," and the boiler is put in.

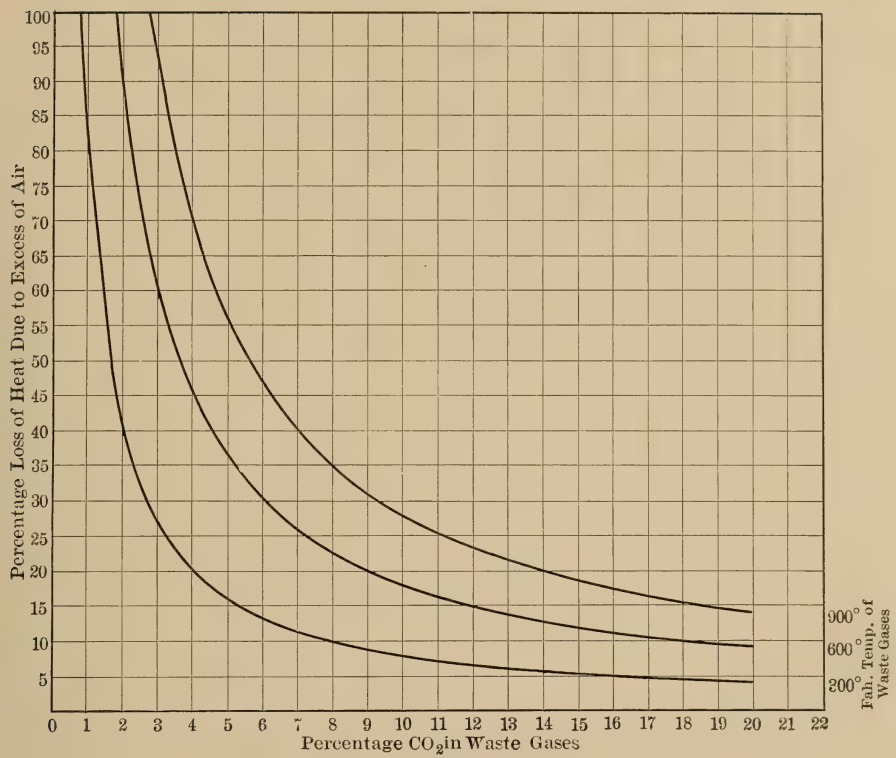
The thicker plates for the same sized boiler will cost you at least 2 per cent. in your coal bill on that boiler unless you increase your boiler heating surface also by 20 per cent.

At first sight this seems an unanswerable argument in favour of the water-tube boiler with its thin tubes, but the water-tube type has disadvantages, chief among which is that the fire is always trying to boil brickwork as well as water.

These facts also show why it is more economical to work boilers at their full capacity and to have as few boilers at work as possible. Not only are radiation losses thus minimized, but the heat-absorbing powers of the remaining boilers are improved.

It may be said that incomplete combustion, radiation, and loss of heat in the chimney are responsible for about 38 per cent. of the theoretical heat value in a boiler working alone, as the results of experiments recorded by Bryan Donkin some years ago, attest.

These experiments are, however, now quite obsolete, seven years mak-



CURVES SHOWING HEAT LOSSES DUE TO VARYING PROPORTIONS OF *CO* AND CO_2 IN THE CHIMNEY GASES

ing ancient history in this connection for, working in connection with an economizer, a good type of mechanical stoker, and a superheater, as much as 85 per cent. can be utilized. Where economy is desired, it is essential that careful firing should be carried out, and the efficiency of the furnace is therefore of the utmost importance.

The actual quantity of air required varies with different fuels, but, taken broadly, it may be accepted that complete combustion is interfered with by lack of air, while an excess of air causes waste of heat.

We do not now propose to give any account of the chemistry attached to the combustion of coal, further than to allude to the analyses of the waste gases. This we consider an essential means of checking the actual efficiency which is being attained in the boiler, as it is by the composition of these gases and their temperature that we are able to tell whether the coal is being burned to its best advantage in any particular furnace.

The waste gases should be analyzed frequently by some simple apparatus, such as the Orsat, and also at odd times, so that the men may not know when their firing will be checked.

Needless to say no *CO* should be tolerated, since 1 pound of carbon burnt to *CO* gives only 30 per cent. of the heat it will give if properly burnt to CO_2. The loss through excess of air is not constant, but depends on the temperature at which the waste gases escape to the chimney.

Referring to the diagram on this page, it will be seen that at 300 degrees, which is a reasonable tempera-

ture for the gases to go up the stack, the percentage of loss varies little between 12½ per cent. and 15 per cent. CO_2,—only about 1 per cent. Now unless the draught is keen and the coal consumption per square foot of grate is high, and the furnace temperature is high in consequence, 15 per cent. of CO_2 is a danger point, and CO should always be looked for. If it is found, our advice is, let a little more air in, either by raising dampers, thinning the fire slightly, or forcing more air in through the bars of such a furnace as the compressed air furnace which we shall again mention later on.

It is safer, in our opinion, to risk a slight excess of air rather than CO, as with the latter there will always be a drop in temperature and almost certainly smoke.

At 600 degrees terminal temperature it will be seen that the losses are much greater, and it is necessary to work nearer the danger line of CO to get even reasonable efficiency.

A good plan throughout the whole day is to collect gradually samples of the flue gases, subsequently subjecting them to analyses. The same observation applies to the ash, samples of which should be collected at the ash pit, ground, and analyzed. In this way it is easily possible to determine whether the coal is being efficiently burned or whether it falls below the standard required. An immense saving can thus be effected, provided that systematic collection and analysis are ensured; unreliable and worthless results are obtained if a slip-shod manner of conducting the tests is countenanced.

Dr. Bourne, in his famous work, "Steam, Air and Gas Engines," says, when summarizing a number of experiments made in Great Britain,—

"A moderately thick and hot fire with rapid draught uniformly gave the best results.

"In all experiments the highest result was always obtained when all the air was introduced through the fire bars.

"Difference in mode of firing would produce a difference of only 13 per cent. (in economy).

"Different fuels require different furnaces, and no one furnace or grate bar is equally good for all fuels."

Now, if in an 8-foot Lancashire boiler 12 cwt. of coal per hour be used, it is obvious that half a cwt. of this should be put in each flue every five minutes. If, as in hand firing, three times this amount be put on every fifteen minutes, a very irregular production of steam is the result, and probably a very regular production of smoke, because 1½ cwts. of coal are put on a fire which has only the same amount of air going through the bars each minute, or, rather, we should say somewhat less than it had before it received this charge of coal.

One would never dream of putting steam into an engine in this way. At every stroke the same quantity of steam is applied, except so far as regulated by an exact governor. A proper mode of firing is here taught at once. Thus one should be able to put a constant amount of coal on the fire per minute with a constant air supply, which is impossible by hand firing. We must therefore choose which system of machine firing will be most economical and effective.

There are a number of machine-firing apparatus on the market that we all know, with varying capacities and efficiencies. In one of these the coal is pushed over a plate on to the grate and carried along by the bars; in another the fuel is fed on to a chain grate, and the coal moves forward with the chain. The chief difference between these two systems is that in the former the bars move beneath the fuel, and if it is small they tend to riddle it through the air spaces.

In the chain grate, on the other hand, there is no movement of the fuel relatively to the links, so that in the latest form of chain grate stokers with fine well-distributed air spaces, this riddling action is avoided.

Where the necessary evaporation can be done on this system, it is a very good one for water-tube boilers, and is absolutely smokeless if not forced. It should be remembered, however, that larger grate area is required for the same duty than with a sprinkling stoker, and in some cases this may be a disadvantage.

The only other system worth considering is the spreading of the fuel over the surface of the fire. Some machines on this system, the sprinkler system, have natural draught, and spread the fuel over the whole grate at regular intervals in small quantities at a time, and thereby get an excellent result, except only that they have no command over the draught, and therefore are most suitable for regular loads. Where the draught is poor, they are unable to get a reasonable duty or efficiency out of a boiler; therefore, it seems that the only system left, if we are to obtain the highest possible result, is one in which the air is forced in through the bars.

If the air be forced in underneath the furnace indiscriminately, it is liable to go to the one clean spot in the fire and thus produce blow-pipe action, which is detrimental to the boiler; but when the air is forced in through the bars themselves, it is compelled to spread itself over the section isolated by each particular bar, and as near perfection is attained as is perhaps possible at the present time. In point of fact, the existence of blow-pipe action in most of the high-temperature furnaces hitherto constructed has been the reason why eminent authorities have expressed the opinion that these high temperatures are detrimental to the boiler. As a matter of fact, it is not the temperature itself, but the existence of great variation in temperatures adjacent to one another in the furnace which does the damage.

Boilers, like those at the Sheffield Lighting Station, have actually been evaporating 11 to 14 pounds of water per square foot of boiler heating surface per hour for three and a half years, and all the leakage due to the intermittent temperature of hand firing has been cured by high-temperature mechanical stokers, with compressed air furnaces.

The coal being spread over the fire at very short intervals of time, say about one-twelfth of a minute, is consumed almost as soon as it falls on the bars, giving up its calorific value in the most effective manner and producing a very high temperature, the advantages of which have been explained.

COAL HANDLING

We now leave the subject of machine stoking and turn to that of the next possible economy,—coal and ash handling plant. A first-class conveyor should possess flexibility of application so that it can be adapted to awkward and complex cases and yet show a large yearly saving on capital outlay. It should be successfully operated with a minimum of power while it should certainly be driven by a simple and reliable device. The cost of handling of each conveyor, including interest on capital expenditure, attendance, oil, motive power, depreciation, and repairs, should work out at a fraction of a penny per ton.

The general construction of the conveyor should admit of interchangeability of its parts, and it should be possible to either decrease or increase its capacity to suit circumstances. It is essental that a good conveyor should be capable of elevating the materials to any required height, that it should be adapted to carry all kinds of material, that its distinctive features should be cheapness in application, simplicity in working, and durability in practice, while it should be quite possible to take the driving power from any convenient means at hand, and the driving power taken per ton of material carried should be small.

One should, however, be lynx-eyed on the question of power, for we

have seen the power taken to drive an elaborate gravity bucket plant gravely stated to be actually less than the foot pounds of work required to raise the coal to the required height, neglecting friction entirely.

As concrete examples of what can be done by the intelligent use of carefully designed elevating and conveying plant in the matter of boiler-house economies, we would invite attention to the automatic machinery for conveying coal from canal barge to boiler furnace, installed at Coventry Corporation Electric Power Station, fully described and illustrated in "The Engineer," of London, for November 3, 1904; the County of London Electric Supply Company's Station; the City of London Electric Supply Company's "Bankside" Station; at the Bristol Corporation's "Avonbank" Power House; and the splendid example at Messrs. Martin, Son & Company, Ltd., at Huddersfield.

Here may be seen complete installations which unload, convey, store, elevate, distribute, weigh, and feed to the boilers, dispensing with costly manual labour, with all its irregularities and disadvantages.

A comparison of costs between the old system which obtained at Coventry and the new, brings out the gratifying fact that considerably over 60 per cent. is saved during the transit from barge to boiler by its inauguration.

At the County of London Power Station, situated on the City Road, and generating about 5,000,000 units per annum for lighting and power, by the old system of unloading the cost of delivering the coal from the barge to the boiler house floor was one shilling per ton, and, should it have been carried up to the bunker room, 2 shillings per ton, whereas, since the present up-to-date installation of automatic elevating and conveying machinery the cost works out at 5 pence per ton, including all labour, the delivery into bunkers and the additional cost of water supplied from the hydraulic power mains used by the crane, while the costs of maintenance are very low, and the repairs are almost nominal.

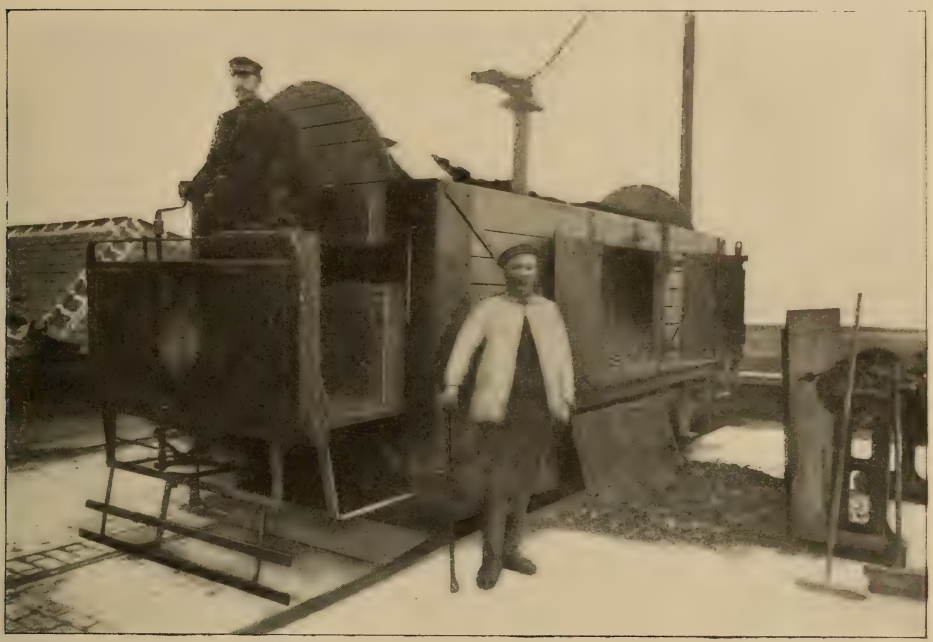
In the words of the resident engineer of that station,—"the steel chain conveyors run splendidly; we never have a breakdown nor any difficulty whatever, and the single man who attends to the hydraulic crane does the whole of the work to the conveying gear, which occasionally requires a slight adjustment. He packs the glands of the crane, greases the bearings, etc., and otherwise looks after the apparatus. During the eight years that this plant has been in use it has only been necessary to remove two links of the chain conveyor."

The seven bunkers which form part of the installation have a total capacity of over one thousand tons. Each conveyor (there are three) can be run independently of its neighbour, or all may be run together.

At the City of London Electric Supply Company's Station, "Bankside" which supplies the whole of the City of London and part of Southwark, and generates current which, in 1904, reached the enormous total of 18,000,000 units, and during 1905 bid fair to surpass this number by an additional 2,000,000, an automatic elevating and conveying fuel-handling plant with mechanical stokers, etc., is at work, and since its installation the costs of dealing with the fuel have been reduced to less than half those that prevailed under the old system.

At the Bristol Corporation Electricity Works, "Avonbank," the coal is raised from the barges by a Bennis coaling tower, a superstructure mounted on a bridge spanning the roadway. The coaling can be carried on at the rate of from 30 to 40 tons per hour, and in this instance, as in those already given, the economy effected is beyond question and highly satisfactory.

At Messrs. Martin, Sons & Company, Ltd., of Huddersfield, there is



AT THE WORKS OF MESSRS. MARTIN, SONS & CO. LTD. OF HUDDERSFIELD, AN ELECTRIC TRAMWAY COALING TRUCK BRINGS THE COAL IN AND DEPOSITS IT OVER A COAL HOPPER FEEDING A CHAIN CONVEYOR

perhaps what we might call one of the most "up-to-date" plants in Great Britain. We believe we are correct in stating that they were the first to make use of an ordinary municipal tramway to bring their fuel in. Tramway lines have been run from the main road right into the works. A special form of side door electric tramway truck was built by Messrs. G. C. Milnes, Voss & Company, with Westinghouse controllers for the purpose.

This electric railway truck, of which a view is given on this page, brings the coal in and deposits it, as depicted, over a coal hopper. This hopper is formed of cast-iron plates supported on joists, which are let into the brick walls for forming the hopper pit. A Bennis steel chain conveyor runs through this coal hopper, taking up the fuel at an angle of inclination of 24 degrees, and then running along over the top of the stoker hoppers, as shown in the illustration on page 374.

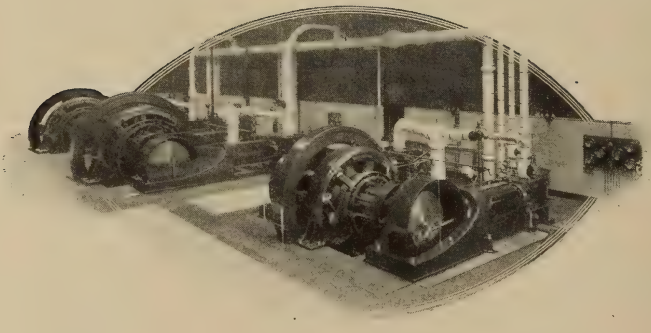
This combined elevator and horizontal conveyor does away with the necessity of providing a separate bucket elevator and coal conveyor. It consists of a channel-shaped trough made of close hard-grained cast iron, $\frac{5}{8}$ inch in thickness, strongly ribbed, 9 inches in width, and 6 inches in depth. The conveyor chain consists of U-shaped links, made of 2 inch by $\frac{1}{2}$-inch open-hearth acid mild steel flats. The links are 12 inch in pitch, and are secured at the joints by means of specially constructed rivets and washers.

The coal is distributed through the shoots into the mechanical stoker hoppers. The stokers are of the Bennis make, with self-cleaning compressed air furnaces. Each of the distributing shoots is fitted with cut-off slides, so that the supply can be stopped in the event of any boiler being taken out of service. The conveyor chain is driven by means of a horizontal drum with drags in two spur-wheel reductions.

The whole of the plant, including the stokers, is driven by a slow-speed engine with 8-inch cylinder and 9-inch stroke.

We consider this boiler house one of the best kept and best equipped in Great Britain. It is maintained in splendid order, and the efficiency of the plant is high. It is a model which may well be followed by others. Each of the high-pressure boilers (the working pressure being 140 pounds per square inch) can comfortably drive 700 indicated horse-power, and the general manager of the company, Mr. Bates, informs us that the saving made by the stokers and conveyors has been very considerable, and such as to fully justify the outlay on the plant.

To sum up,—science has exploded the antiquated cry, "There is nothing to beat hand firing." There is! The powerful, efficient and reliable high-temperature machine stokers have come to stay, and with well-designed and well-managed boilers, flues, chimneys and the many modern accessories of a modern boiler room, will enable manufacturers to burn cheap coals economically and smokelessly, forestall the efforts of the Royal Commission on Coal Supplies, make money for themselves and incidentally turn our cities into the smokeless Utopias of our dreams.



ELECTRICITY IN THE FOUNDRY

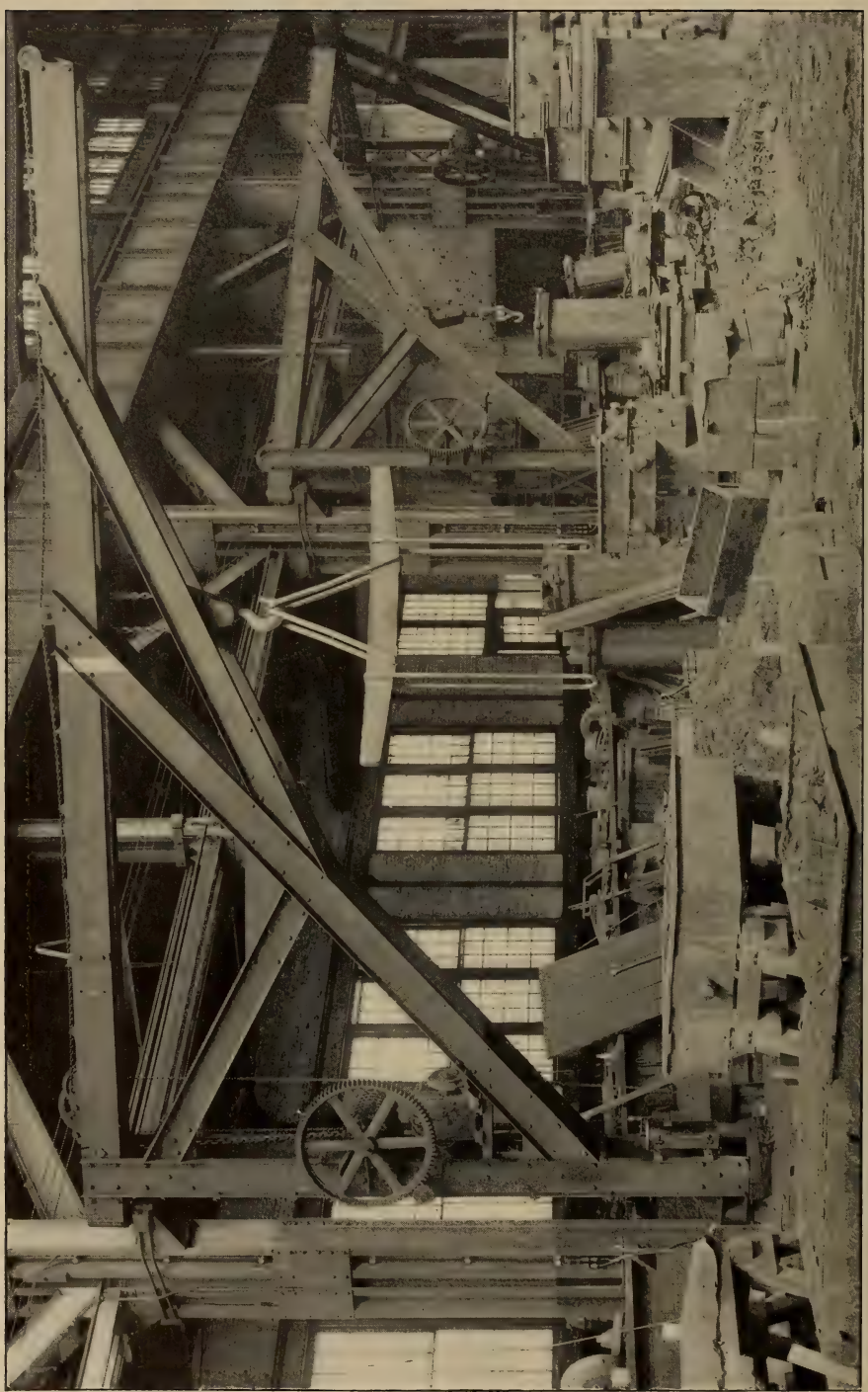
By H. S. Knowlton

ONE of the most interesting features of modern foundry practice is the part played by electricity in the economical production of castings. Few departments have undergone greater changes for the better in later years than the foundry, and the most casual inspection of the better class of recent installations brings to light the fact that the reduction of waste is becoming more and more the object of administrative attention.

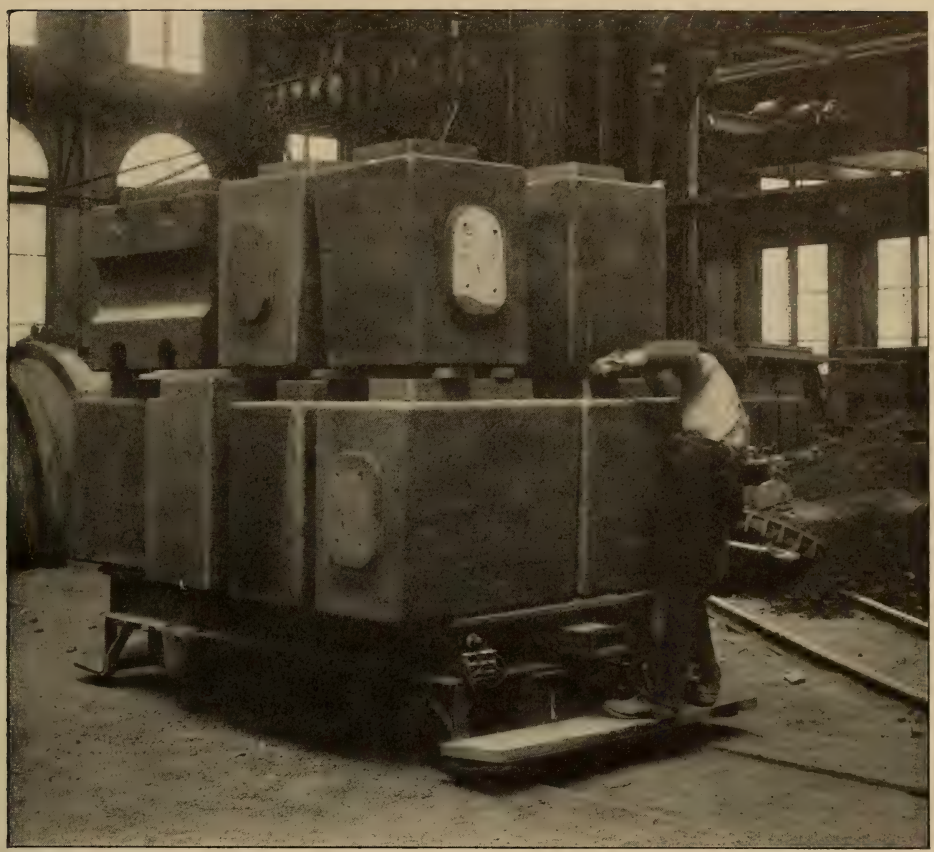
Even under the most favourable conditions, foundry work is difficult labour for the numerous employees required in the operations performed; the atmosphere is certain to be smoky and dusty, and it is a hot and trying task to handle, with accuracy and caution, ladles partly filled with molten metal. As the demands upon the foundry increase, the space inevitably becomes more crowded, and the possibility of accident grows less remote. Any steps, therefore, which can be taken to improve the working conditions without unreasonable expense, are highly justified, and the later foundries designed on broad-gauged principles bear ample evidence of the desire of the managers to increase the convenience and comfort of their employees.

In this connection, well lighted and well ventilated offices have been provided for the foremen and their assistants, while comfortable wash-rooms, ample locker space, and mod-

POURING LARGE CASTINGS IN THE WESTINGHOUSE FOUNDRY WITH THE ASSISTANCE OF AN ELECTRIC CRANE



ONE OF SEVERAL PORTABLE JIB-CRANES IN THE FOUNDRY OF THE GENERAL ELECTRIC COMPANY, SCHENECTADY, DRIVEN BY A 5-H. P. MOTOR. THE COLUMNS OF THE FOUNDRY ARE EQUIPPED WITH PINTLES SO THAT THE CRANES MAY BE TRANSFERRED FROM ONE COLUMN TO ANOTHER BY THE TRAVELING CRANE TO MEET THE CONDITIONS OF THE FOUNDRY WORK FROM DAY TO DAY THE JIB-CRANES MAY THUS BE USED WITHOUT TYING UP THE TRAVELING CRANE



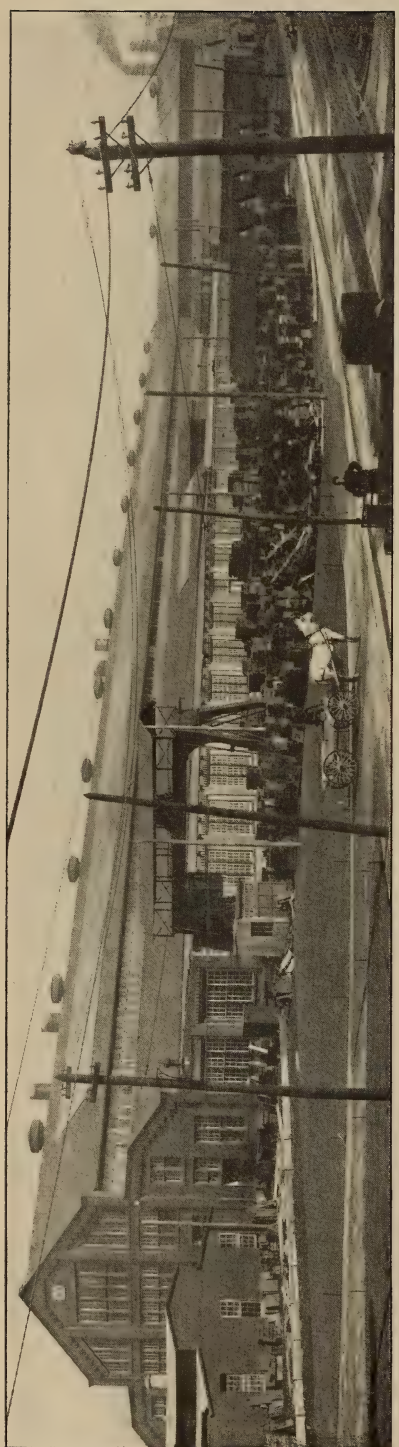
AN ELECTRIC STORAGE BATTERY AUTO TRUCK MADE BY THE WESTINGHOUSE MACHINE CO., PITTSBURG, TRANSFERRING CORES IN THE COMPANY'S TRAFFORD CITY FOUNDRY

ern toilet facilities have been placed at the disposal of the subordinates.

In this general improvement of conditions, electricity accounts for more than is often realized. It may seem ludicrous to urge the virtues of cleanliness under foundry conditions, and yet every machine or contrivance which when added to the existing equipment, performs its work without introducing escaping steam, smoke, dirt, excessive heat or other troublesome features into the already overburdened atmosphere, is just so much clear gain to the working force. This is where the electric motor surpasses every other form of power equipment, with the exception of pneumatic hoists and hammers, in foundry practice.

Space is immensely valuable in the commercial foundry, and the advantage of placing the motor against the wall or in some other out-of-the-way situation has long been appreciated. Compactness, cleanliness, high efficiency in operation, and the ease of remote control, all bear upon the problem of foundry power.

The service is doubtless severe upon the motors, for it is difficult to secure any sort of ventilation, enclosed frames being an absolute necessity when direct-current equipments are used, on account of the dust and flying particles of metal. For constant-speed service, therefore, the induction motor easily leads the way, but care should be taken in every instance to specify designs



THE IRON FOUNDRY OF THE GENERAL ELECTRIC CO., AT SCHENECTADY, NEW YORK. A 10-TON ELECTRIC GANTRY CRANE FOR HANDLING FLASKS IS SHOWN SPANNING THE FLASK AND STORAGE YARD

which provide dust-proof bearings.

The variety of uses to which motors may be put in foundry practice is greater than one might at first suppose. The storage battery locomotive, and sometimes the motor car taking current from an overhead or underground trolley, suggest themselves as valuable in the handling of pig iron and coke,—a process too often carried on by muscular effort, which, when capitalized, amounts to a surprising figure.

Without the electric traveling crane, modern foundry practice on a large scale would be so handicapped that anything like the present rates of production would be impossible. From the time when the pig iron, coke, sand, etc., enter the premises to the time when the completed casting is shipped to the machine shop, it is exceedingly important that provision be at hand for continuous transportation at the lowest cost reconcilable with rapid work.

In a certain foundry with which the writer is familiar, about 40 tons of iron are poured each day. The ladles, flasks, etc., are handled by one 15-ton and two 20-ton electric cranes, and yet the demands upon these cranes are so frequent that within a few days a certain job was obliged to wait nearly two hours before one of the cranes could be utilized upon it. One might say in such a case that poor design or poor management was at the bottom of the trouble, but the foundry is equipped with seven longitudinal and four transverse narrow-gauge tracks, and a large number of small electric and pneumatic hoists in addition to the overburdened cranes, and the management are constantly on the alert to adopt improved methods. The illustration simply emphasizes the immense importance of providing very liberal crane facilities, and there is no doubt that the accelerating power of series motors is quite as valuable proportionally in the foundry as it is in rapid-transit street railway service.

Even under favourable conditions a great deal of time is often lost by employees who are obliged to wait for the cranes after the flasks are prepared, to receive the molten metal. On a smaller scale, the 1 or 2-ton electric hoists are equally essential to the rapid handling of the work.

In a foundry recently visited, electric elevators are employed to transfer 3000-pound cars carrying pig iron and coke to and from the charging floor of the cupola furnaces, and here the compactness of the motor-drive particularly commends itself. After the cars have been discharged, they are sent down an inclined track upon an elevator which descends automatically to the first floor, the signal for releasing the car being given by an incandescent lamp on the charging platform which lights whenever the elevator is at the top of its travel, and thus ready to receive an empty car. In the confusion which usually exists in a busy foundry, the use of such electric signals is a noteworthy convenience.

The amount of power required by the different machines varies widely; the cranes, elevators, and blowers naturally consume the bulk of the energy utilized. In the new foundry of the B. F. Sturtevant Company, at Hyde Park, Mass., there are two Whiting cupolas, 56 inches and 72 inches in diameter, respectively. The smaller cupola is supplied with an air blast forced in by a 30-H. P. blower, and the larger is supplied by a 40-H. P. blower, both blowers being driven by belted motors supported in an enclosure upon the charging platform. These large motors are thus well out of the way, and as they require little attention are inex-

A PORTABLE ELECTRICALLY DRIVEN SAND SIFTER MADE BY MESSRS. GOULD & EBERHARDT, NEWARK, N. J., U. S. A. USED IN THE FOUNDRY OF THE GENERAL ELECTRIC CO., SCHENECTADY

A 25-TON THREE-MOTOR OVERHEAD TRAVELING CRANE IN THE STEEL FOUNDRY OF MESSRS. ERNEST SCOTT & MOUNTAIN, LTD., NEWCASTLE-ON-TYNE

IN THE WEST ALLIS FOUNDRY OF THE ALLIS-CHALMERS CO., WILWAUKEE, SHOWING ONE OF THE ELECTRIC MOTOR-DRIVEN TRAVELING JIB-CRANES BUILT BY MESSRS. PAWLING & HARNISCHFEGER OF MILWAUKEE

pensive to operate and maintain. There is no room in the modern foundry for cumbersome equipment that is liable to block the aisles and craneways.

In the brass foundry, the power requirements are usually very moderate as the machines driven are not large. Thus, in a certain case, a 5-H. P. motor suffices to drive a blower for four crucible furnaces and one reverberatory furnace used in melting babbitt and similar soft metals, a sprue cutter, magnetic separator, tumbling barrel, and emery wheels. As in the iron department, enclosed types of motors are necessary.

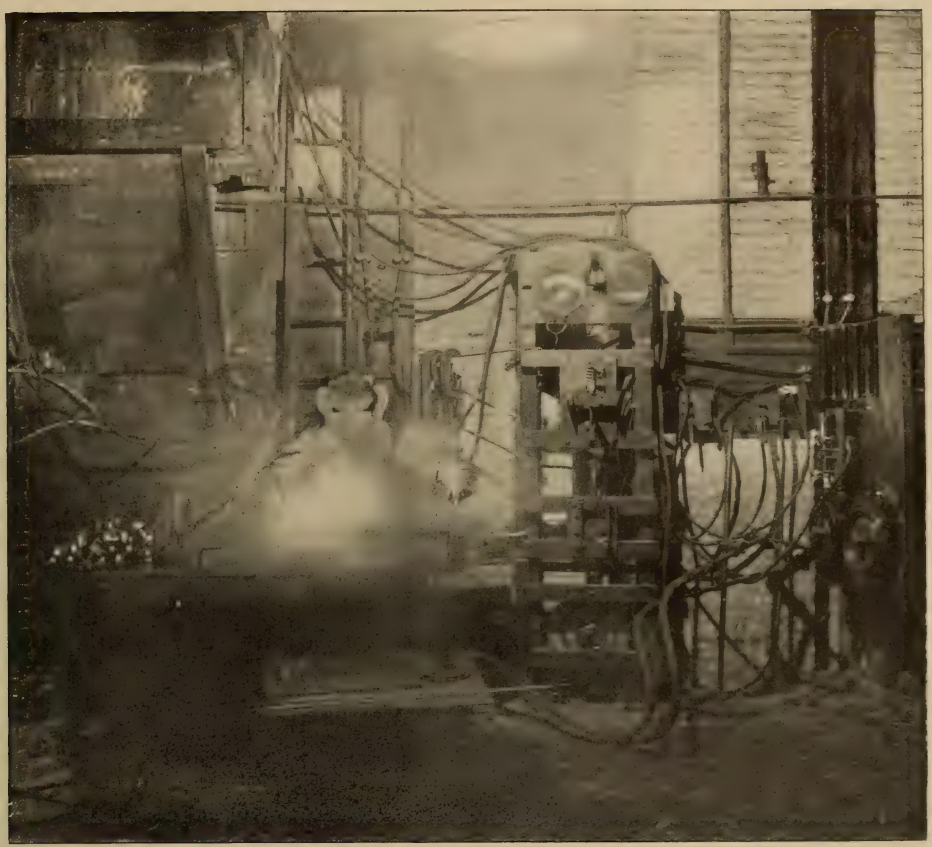
Wire straighteners, tumbling barrels, cinder mills, emery wheels, and air compressors for the operation of chipping and snagging tools, blowing out castings, etc., are all readily and conveniently driven by electric motors. About 30 horse-power are required for this work in the Sturtevant foundry, exclusive of the compressor, which is located at the company's power house.

In general, the group driving of

foundry machinery has proved advantageous, as the equipment is in frequent if not constant use, and the amount of shafting and belts required is small. There seems at present to be little object in going to the additional expense of installing direct-connected motors. The matter is very different from the case of the machine shop, for selective hand labour plays an important part in foundry work.

The problem of artificial light in the smoky and dusty atmosphere of a foundry is a difficult one to solve. Almost every form of enclosed lamp becomes so quickly coated over with dirt, that in many cases the open-arc lamp seems to be about the only successful illuminant, and unless this is employed pretty liberally the result is not satisfactory. Fortunately, the molten metal gives off a considerable amount of light, so that pouring is facilitated even in cases where the electric lighting is inadequate. One certain point, however, is that electricity gives better satisfaction than gas, and oil is quite out of the race. The mercury vapour lamp ought to

A STORAGE BATTERY LOCOMOTIVE BUILT BY THE C. W. HUNT CO., OF WEST NEW BRIGHTON, STATEN ISLAND, NEW YORK, IN THE FOUNDRY OF THE SINGER MFG. CO., ELIZABETHPORT, N. J.



ELECTRIC WELDING IN THE FOUNDRY OF THE BALDWIN LOCOMOTIVE WORKS, PHILADELPHIA

be useful, as it illuminates large areas.

As far as the writer is aware, the electromagnet in commercial sizes has not been used to much extent in foundry practice. There ought to be a field for this, particularly in the economical handling of pig iron. The charging of small cupola furnaces is now largely done by hand labour, the custom being to lift the pigs from the cars and toss them by manual force into the cupola.

In a given case, three men at $10 per week each, are required to charge a 6-foot cupola, which means over $1500 per year for a task which ought to be possible with one man and suitable machinery. The point to be kept in mind is the necessity of evenly charging the cupola, and for this, human intelligence cannot well be dispensed with. Given an electromagnetic hoist at the furnace door, with an adjustable swing and suitable runways, there ought to be no great difficulty in disposing of two men per cupola, which would pay good interest, depreciation, maintenance, and operating expenses on the investment.

Labour-saving devices are some of the most valuable assets of large blast furnaces and steel mills, and it is certainly worth while to apply the labour-saving principles on the smaller foundry charging floors. The electromagnet will pick up almost anything in the line of waste iron that can be put into a charging car, and there ought to be a chance in the foundry for its efficient application.

THE CONDITIONS OF MECHANICAL DRAUGHT PRODUCTION

By Walter B. Snow

THE two elements which contribute most largely to the economic value of any fuel are carbon and hydrogen, which exist in different proportions in the various classes of coal utilized for steam production. Combustion results from their union with the oxygen of the air which combines with carbon to form carbonic acid, and with hydrogen to form water. Carbonic oxide, the product of the imperfect combustion of carbon through lack of oxygen, will become carbonic dioxide or carbonic acid by the further addition of oxygen.

The amount of air theoretically required for the combustion of average coal or coke is about 12 pounds per pound of fuel. But this quantity will serve only when every individual atom of oxygen comes in contact and unites with corresponding atoms of hydrogen or carbon. The arrangement of the fuel on the bed and other circumstances make it impossible to obtain this condition in actual practice. It becomes necessary, therefore, to supply the air in such excess as to make good any local deficiencies.

Although tests have shown a range of supply all the way from 50 to over 300 per cent. in excess of that theoretically required, it may be generally accepted that in good practice with natural draught and hand-firing the volume is seldom less than twice that chemically required. With mechanical draught it is, under ordinary conditions, possible to materially reduce this amount. It is therefore evident that the efficiency of both the fuel and the boiler is primarily dependent upon, and largely affected by, the air supply. Hence, the vital importance of selecting the best method of draught production.

In boiler practice the force of the draught must be expended in two ways:—

First, a portion is necessary to overcome the resistances of the grate and the fuel upon it, of the combustion chamber, flues or tubes and uptake, and of the means of connection to the source of draught, be it fan or chimney. The sum of these resistances is a measure of the pressure head.

Second, the draught must, in addition, be sufficient to impart to the air the velocity necessary to furnish the amount requisite for the direct purposes of combustion. This is a measure of the velocity head. With a constant total head, any change in the resistances immediately alters the relation between the pressure and velocity heads. Thus, for instance, a thicker fire or finer coal increases the resistances and reduces the portion of the draught available for the production of velocity. As a result, the air supply becomes inadequate, and greater total intensity of draught is necessary to maintain the original combustion rate.

A careful study of boiler resistances is necessary to a thorough consideration of the practical conditions of draught production. In the case of a stationary boiler furnace of ordinary construction, Prof. Gale found the various pressures, expressed in pounds per square foot, given in Table I.

This total static pressure, here given in pounds per square foot, is equivalent to 0.28 ounce per square

TABLE I.

Required to produce entrance velocity (3.6 feet per second)	0.013
Required to overcome resistance of fire grate	0.91
Required to overcome resistance of combustion chamber and boiler tubes	1.23
Required to overcome resistance in horizontal flue	0.06
Required to produce discharge velocity (11.2 feet per second)	0.085
Total effective draught pressure	2.298
Back pressure due to friction in stack	0.19
Total static pressure produced by chimney	2.488

inch or 0.48 inch of water. From these results it is evident that only about 4 per cent. of the total draught pressure was actually expended for the production of velocity and the movement of air. Designs for draught-producing apparatus are not, therefore, to be based solely upon the volumetric requirements. If this were the case, a low chimney or a large slow-running fan would meet the requirements. In reality the design must first contemplate the creation of sufficient intensity of draught, and then provide capacity for the necessary amount of air.

In the case of a chimney the maximum draught, being dependent upon its height, is constant for the same temperature, and regulation of the combustion can be secured only by throttling the air supply. With a fan, however, the intensity of the draught may be instantly changed from zero to the maximum with a proportional increase in the air volume. It must already be evident that only under the latter condition can the requirements of combustion most readily be met, for it is manifest that in order to maintain constant steam pressure with varying fuel conditions there must be comparatively great and rapid changes in the draught.

The chimney as a means of creating movement of air depends upon the heating of that air, by which a difference in density is produced. The heat thus employed is, however, absolutely wasted, so far as its utilization for other purposes is concerned. Any attempt to extract more of the heat from the gases as they escape from the boiler must, with a given chimney, result in a reduction of the draught. This inherent loss amounts to about 20 per cent. with ordinary coal when the gases are at 500 degrees F. and the excess of the air is 100 per cent.

Heat being the agency by which the air movement is brought about, the efficiency of a chimney must be measured by the amount of heat expended for that purpose. As heat is transformable into work, the efficiency is, therefore, to be measured by the number of foot-pounds of work represented by the pressure difference exerted through the distance moved, as compared with the number of foot-pounds represented by the total amount of heat expended.

It may be shown that, when no work is lost in friction, and the respective temperatures of the external air and the chimney gases are 62 degrees and 500 degrees, the theoretical efficiency of a chimney 100 feet high will be only about six ten-thousandths. In practice the resistances of the chimney, the cooling of the gases and other causes combine to reduce even this extremely low efficiency.

If, in the place of the chimney, an engine-driven fan of proper size be substituted, the resultant of the efficiencies of the steam boiler, the engine, and the fan, together with the loss by friction in the apparatus may be reasonably taken at about 4 per cent. The work done, or its equivalent in heat units expended to produce the given result, will therefore be about seventy times as great in the case of a chimney as in that of a fan.

All other questions aside, the fan is therefore far more economical than the chimney as a device for producing air movement. This economy means that when a fan is employed, the surplus heat can be utilized and the gases reduced to a minimum temperature before they escape. Not only is the fan more economical as a device for moving air, but as

will be shown later, its cost is far less than that of a chimney.

The methods of application of mechanical draught may be broadly classified under two heads,—the plenum and the vacuum methods. Under the plenum or "forced" draught method, the air may be supplied in either of two ways,—first by making the ashpit practically air-tight, and forcing the air into it; second, by making the fire room itself practically air-tight and maintaining therein the required air pressure.

Under the vacuum or "induced" method, there is practically only one means of application,—the introduction of an exhaust fan in the place of the chimney. A short and comparatively light stack usually serves to carry the gases sufficiently high to permit of their harmless escape to the atmosphere.

Evidently, the method of application to be adopted must depend upon the circumstances. It cannot be said that under all conditions any of these three principal methods, or of their numerous modifications, is superior to the others.

The application of mechanical draught presents a threefold opportunity for increased economy in steam production. First, in the reduction of avoidable loss. Second, in a decrease in the first cost and resultant fixed charges on the entire steam generating plant; and third, in a reduction in the operating expenses, principal among which is the cost of the fuel. In addition, mechanical draught possesses certain advantages which cannot be directly measured by money values. Such are its peculiar adaptability to the requirements, its independence of climatic conditions, its flexibility, and the like. These various features will be considered in the order here presented.

A resultant efficiency of 100 per cent. on the part of either the coal or the boiler is an absolute impossibility, because of certain inevitable losses incident to the combustion of the coal and the operation of the boiler. Although under the best conditions over 80 per cent. of the full calorific value of the fuel may be utilized in the production of steam, yet it is true that this high standard is seldom reached in ordinary practice. An efficiency of only 60 to 70 per cent. is common, and even 50 per cent. is far from exceptionally low.

The principal unavoidable losses are represented by the heat necessary to raise the minimum quantity of air and gases to the temperature of the steam generated, and that required to convert into steam the water present in the fuel and to raise it to this temperature. The important losses which are more or less avoidable include the heat expended in raising the temperature of the flue gases above that of the steam within the boiler, that lost by radiation from the shell and setting, and the result of incomplete combustion as evidenced in smoke and carbonic oxide and in unconsumed carbon in the ashes.

Reduction in the loss of heat in the escaping gases may be secured by decreasing the volume of air supplied in excess of that chemically required, and by providing means for the abstraction of heat from the gases after they leave the boiler.

The loss resulting from the supply of air in excess of that necessary for perfect combustion is twofold in its character:—

First, the excess of air entering the furnace is heated by the burning fuel, thereby lowering the temperature of the mixture of gases and air in the furnace below that which would prevail if the gases only were present. As a consequence, the rate of absorption of heat by the water is reduced, for it is dependent upon the difference in temperature between the water and the gases.

Second, owing to larger volume and higher velocity, there is less time to part with the heat. As a consequence, the temperature of the mix-

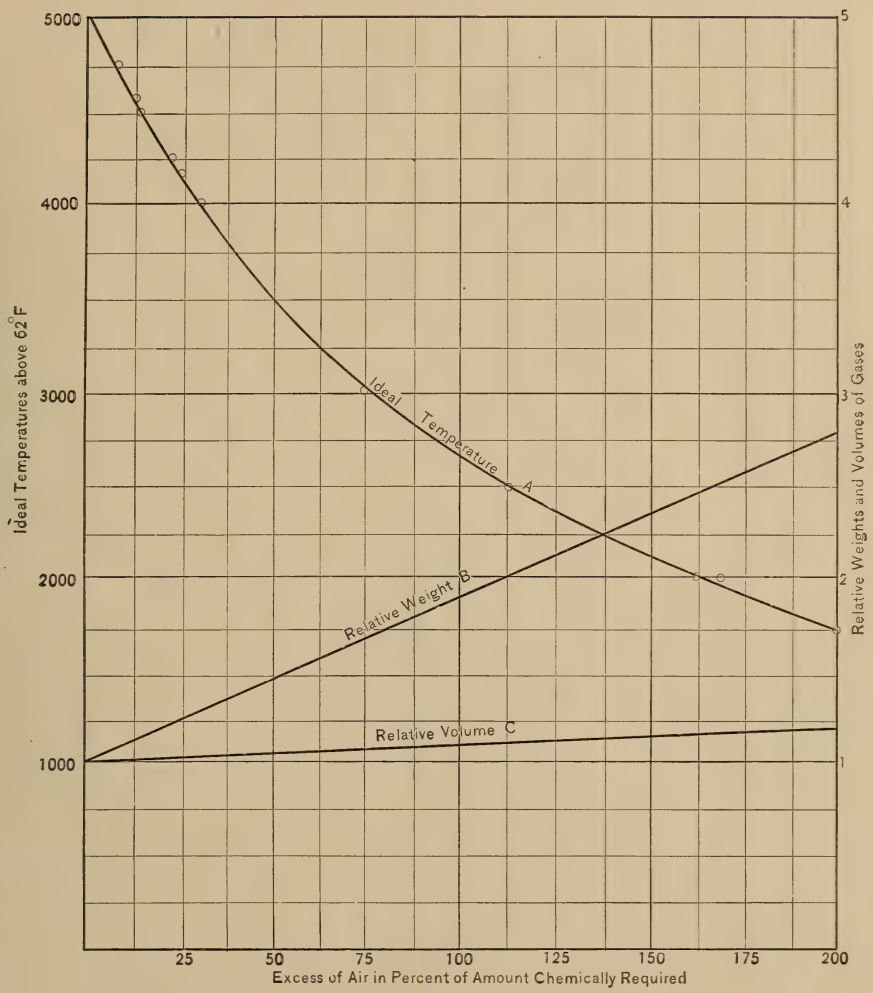


FIG. 1.—EFFECTS OF EXCESS OF AIR

ture of gases and air escaping to the chimney is higher than would be the case if there were no excess of air; while the increased volume is such that the total amount of heat thus carried away, without exerting any useful effect, is greatly increased. In other words paradoxical as it may seem, the larger the volume of air supplied the higher will be the temperature of the escaping gases, within the ordinary range of boiler practice.

In the accompanying diagram, Fig. 1, the curve *A* serves to indicate, for an ordinary anthracite coal, the ideal temperatures in the heart of the fire corresponding to various amounts of air in excess. The weight of the products of combustion as shown by curve *B* naturally increases with the amount of air, but the volume of the gases at the ideal temperature above 62 degrees, represented by curve *C*, remains practically constant, because the expansion of the increased volume is relatively less at the lower temperature.

A high furnace temperature and low stack temperature, other things equal, are evidently conducive to greater efficiency. It has just been shown that such conditions are in-

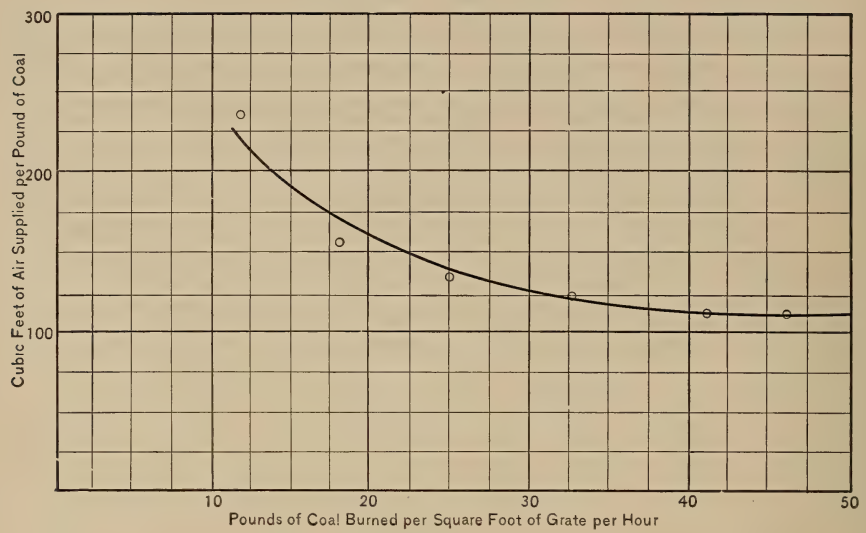


FIG. 2.—AIR SUPPLY WITH DIFFERENT RATES OF COMBUSTION

cident to a reduction in the excess of air supplied. But perfect combustion with a small supply of air will result only when the air is intimately distributed throughout the fuel. For such intimacy of contact, intense draught and a clean and reasonably thick fire are necessary,—conditions which may be most readily maintained by means of mechanical draught.

With a thick fire the air is compelled to come in contact with a greater amount of fuel and has a better opportunity to promote perfect combustion. This points to the efficiency of reasonably high rates of combustion. When secured under proper conditions, with a given grate area and boiler, any increase in the rate must be accompanied by an increase in the total air supply, and hence a probable increase in the temperature of the escaping gases. But if, the total consumption remaining the same, the grate area be reduced, the rate of combustion per square foot of grate will of necessity be increased, and the efficiency of combustion may be greater. In fact the proportion of surplus air required appears to diminish as the rate of combustion and the general temperature in the furnace are increased. Mechanical draught naturally opens the way for increased efficiency by facilitating the adoption of grates of diminished area in combination with accelerated combustion.

With a decreased supply of air, the intensity of the fire is increased, its temperature is higher, more heat is radiated to the exposed boiler surfaces, and more is taken up by the gases. Furthermore, the diminished superficial area of the grate and of the exposed interstices between the fuel necessitates a higher velocity to secure the admission of a given volume of air. The increased velocity, in turn, requires greater draught or air pressure. If a given grate be reduced one-half, and the rate of combustion be doubled, the same volume of air will have to travel through the exposed interstices at twice the velocity. But the pressure or vacuum required to produce this velocity will be four times as great, and, as a consequence, the air will be forced or drawn into spaces between the fuel which it could not reach under less impelling force. Much more intimate contact and distribution are the results. Less free oxygen passes through the fuel bed unconsumed,

and for a given supply of air a higher efficiency of the fuel is attained.

The readiness with which mechanical draught can be supplied in connection with mechanical stokers, the thoroughness of the distribution of the air and the evenness of the fire are the essential factors in their increased economy over the ordinary grate. The simplicity of application of mechanical draught is, under these conditions, clearly evident.

In experiments with a Wilkinson stoker, Jay M. Whitham has shown, as indicated in Fig. 2, the most remarkable result of almost perfect evaporative efficiency with a combustion rate of 45.4 pounds, and an actual deficiency of 11.2 per cent. in the air supply below the chemical requirements. The relation of air supply to rate of combustion is made clear by Fig. 2.

Undoubtedly the source of greatest loss in boiler and fuel efficiency lies in the usual high temperature of the escaping gases. The influence thereon of an unnecessary excess of air has just been indicated. In seventeen independent boiler tests, Donkin and Kennedy found the heat lost up the stack when no economizer was used, to range between 9.4 per cent. and 31.8 per cent. of the total heat of combustion. The theoretical losses with 100 per cent. excess of air, and different temperatures of the escaping gases above the atmosphere are clearly presented in Fig. 3 for an ordinary coal having a heat value of 11,720 British thermal units.

With a chimney a comparatively high temperature of the rejected gases is an absolute necessity for the production of the draught. Its production by means of a fan, is, on the other hand, independent of the temperature of the gases, and the opportunity is, therefore, presented to utilize the heat which is a positive and unavoidable loss in the case of a chimney.

Here lies one of the greatest opportunities for increasing boiler efficiency. Although additional surface may be obtained by reducing the size of the tubes and increasing their number, or by ribbing them, or by in-

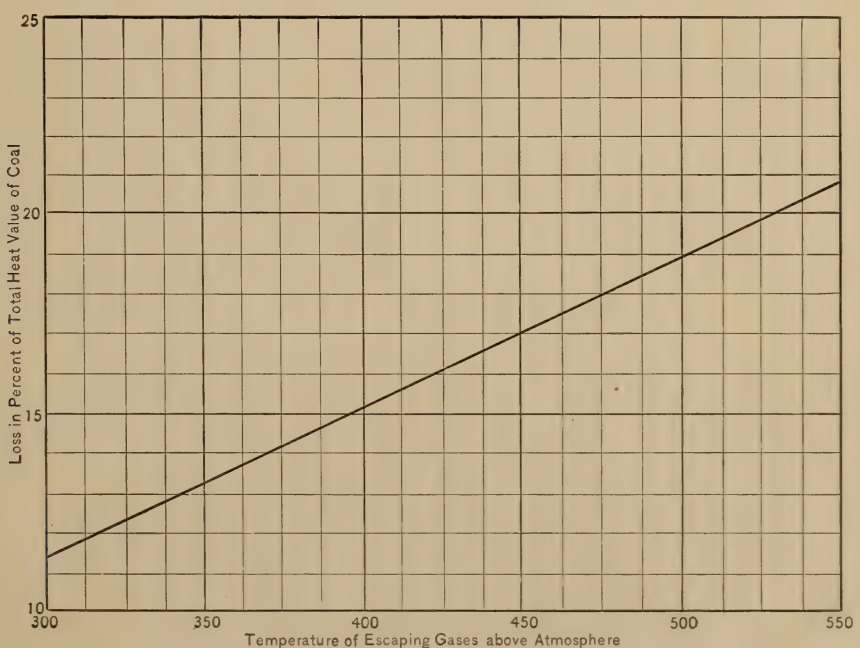


FIG. 3.—LOSS OF EFFICENCY DUE TO TEMPERATURE OF ESCAPING GASES

troducing retarders, it is usually customary to abstract the surplus heat from the gases by some means in a sense independent of the boiler. It may then take the form of a feed-water economizer, or of a device for abstracting the heat from the gases and transferring it to the air supplied to the fuel. The results obtained by any of these methods have, in the case of chimney draught, always been restricted by the cost of the excessively high chimney necessary to produce the requisite draught with the decreased temperature and increased resistance.

The simplicity and efficiency of mechanical draught, however, obviate this difficulty and make possible the attainment of a much lower final temperature of the flue gases with a corresponding increase of efficiency. So fas as production of draught is concerned, the gases may be cooled down to atmospheric temperature, but the practical limit is necessarily above this, because of the expense of the abstracting apparatus required. The following actual results were secured in different boiler plants, each equipped with economizer and mechanical draught:—

Plants Tested	Gases Entering Economizer Degrees F.	Gases Leaving Economizer Degrees F.	Water Entering Economizer Degrees F.	Water Leaving Economizer Degrees F.	Increase in Temperature of Water
1	650	275	180	340	160
2	575	290	160	320	160
3	470	230	130	260	130
4	500	240	110	230	120
5	460	200	90	230	140
6	440	220	120	236	116
7	525	225	180	320	140

Under favourable conditions a well-installed economizer may readily save enough in fuel to represent an annual dividend of 50 per cent. upon the investment.

From a commercial standpoint, the application of mechanical draught exerts a marked influence upon the aggregate first cost of a steam-boiler plant. Not only will the apparatus cost far less than the chimney, but when applied for induced draught production it can usually be placed overhead, thereby avoiding the use of valuable floor space. Comparative costs of chimney and mechanical draught installations are given in Fig. 4.

Owing to its handling cold air instead of hot gases of relatively double the volume, a forced draught equipment costs materially less than one installed on the induced principle. The losses resulting from incomplete combustion are manifestly due to inadequate supply or imperfect distribution of the air. The presence of smoke indicates an absolute loss. Although this seldom exceeds 1 per cent. in ordinary practice, even this amount may be almost entirely eliminated, and the smoke nuisance may in most cases be practically avoided by proper regulation of the air supply and the surrounding of the fire with a heat-resisting combustion chamber.

The loss of efficiency which ensues from the escape of carbonic oxide, unconverted into carbonic acid, is due to the much smaller amount of heat developed by the incomplete combustion of carbon into the former gas. Fortunately, in the best practice of to-day, the carbonic oxide present in the chimney gases is usually well within 1 per cent. of the total volume. Conditions are, however, frequently found under which such good results do not obtain. When a fire is suddenly thickened and deadened by additional coal, and large volumes of gas are given off, there is a demand for an increased air supply for the purposes of combustion. At the same time there is a tendency to clog the passages through which the air has previously passed, and thereby to prevent complete combustion at the surface of the fire. At the same time, for perfect conditions, more air under greater pressure should be admitted,

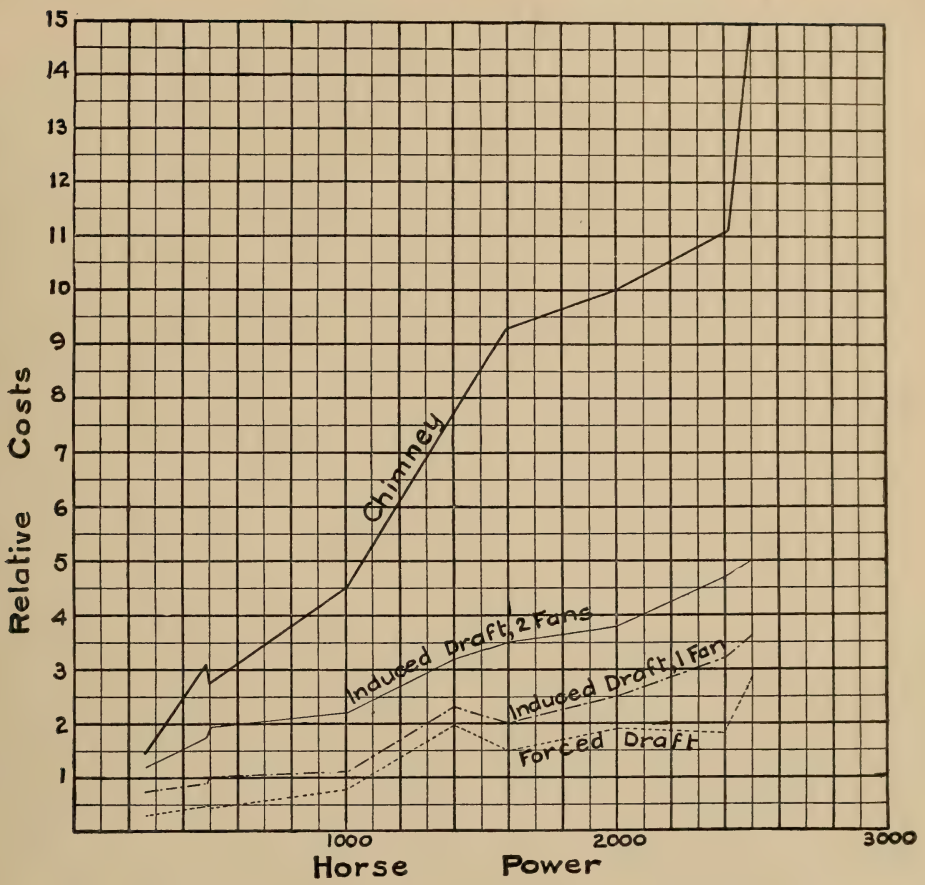


FIG. 4.—COMPARATIVE COSTS OF CHIMNEYS AND MECHANICAL DRAUGHT

as is possible under the positive action of mechanical draught, arranged to operate automatically, and thereby exactly measuring the volume and pressure in proportion to the requirements.

The relative amount of unconsumed coal in the ashes is dependent upon the completeness of combustion, and upon the original size of the coal or its tendency to decrepitate, as well as upon the size of the free spaces through the grates. The smaller the coal, the larger the amount of inherent dust, and the greater the difficulty of securing perfect combustion. It has been conclusively shown that such fuel can be successfully burned only upon special grates, with an intensity of draught such as can be most economically produced by mechanical means.

The largest and most important factor in the operating expense is the cost of the fuel itself, which should be measured, not by the number of pounds, but by the available heat units obtained for a given price. In this cost are properly included the transportation charges, the expense of getting coal into the boiler house and putting it into the furnace, as well as taking out and carrying away the ashes.

The ability to utilize cheap fuels is an inherent advantage of mechanical draught, due to the fact that such fuels being, as a rule, finely divided, with a large percentage of dirt and ash, require an intense draught for their combustion.

It appears that the combustion of small anthracites is more perfect

when the coal remains undisturbed, or as nearly as possible in the condition in which it was put upon the fire, instead of being turned over so that the partially consumed and unconsumed coal are mixed together.

Whatever the size of these smaller grades of fuel, certain special furnace arrangements are necessary. The smaller they are, the more extensive and expensive the appliances, and for each special arrangements are necessary. It is, therefore, undesirable and positively uneconomical to mix the sizes. Thus a mixture of dust with pea or chestnut coal, while burning more freely because of the easier passage of air through it, will not give so good evaporation results as an intermediate size containing less of the larger and the smaller pieces or dust, that is,—having all of its pieces nearer one size. This difference is due to the fact that in the mixture the fine coal is completely consumed before the larger pieces.

The advantage of mixing a slight amount of bituminous coal with the smaller anthracites is well known. The somewhat glutinous character of the former, when burning, serves to make a more coherent mass of the entire body of fuel, thereby preventing the dust from being blown through the flues or dropped through the grates, while keeping the bed more open and thereby increasing the rate of combustion. Culm and rice coal thus fired give results in total evaporation which cannot be reached by the same anthracites alone.

It is true that, as the quality of coal grows poorer and the size of the particles less, it becomes more necessary to provide some special form of grate or stoker for its proper burning. But the burning of cheap fuel by mechanical draught will, under perfect conditions, show a decided saving, after due allowance is made for fixed charges on the special furnace arrangements, and for the cost of operating the fan. In general practice, a mere change of grate bars is sufficient to adapt a boiler for burning almost clear yard screenings by means of mechanical draught.

A reduction of over $125 per week, equivalent to $6500 per year, has been made in actual practice in the case of a boiler plant of 1000 H. P., by the introduction of mechanical draught costing about $550, and the burning of buckwheat and yard screenings with a slight mixture of Cumberland. The possible savings, of course, depend primarily upon the relative costs of fuels; in other words, upon the geographical location of the plant. The higher the scale of prices the greater the possible savings.

The extensively applied system of burning shavings and wood refuse discharged through dust collectors, is essentially allied with mechanical draught, although the fan is here primarily applied for the conveying of shavings to the furnace, while the air is incidentally supplied to meet the requirements of combustion.

In the practical application of mechanical draught for the burning of any kind of fuel, the flexible character of the equipment must be duly recognized. The apparatus must be designed for maximum requirements, but so proportioned as to economically meet average conditions.

UTILIZING EXHAUST STEAM

IN THE LOCOMOTIVE WORKS OF THE GRAND TRUNK RAILWAY AT MONTREAL, CAN.

By Alex A. Maver

HOW to utilize to the best advantage the exhaust steam from steam-driven tools, is a question of general interest to steam users. Frequently additional boilers have been put into boiler plants on account of increased steam requirements, where, had due consideration been given to the importance of making use of exhaust steam to the fullest extent, the additional boilers might have been unnecessary, and with this important advantage, too,—extra boilers mean increased fuel consumption, whereas, feed water at higher temperature due to the employment of the waste steam heat means increased steaming efficiency and decreased consumption of fuel.

This was the experience of the writer at the locomotive works of the Grand Trunk Railway at Montreal, where, on account of a shortage of steam, due to increased consumption, the matter of remodelling the entire boiler plant was under consideration,—a proceeding that would have involved a heavy outlay. Instead of remodeling the boiler plant, however, it was decided to make use of the exhaust steam heat, which was then being dissipated into the atmosphere. Accordingly, a system was established of conveying the exhaust from the various stationary engines, steam hammers and pumps to a jet condenser, from which the water flows to hot wells, and is then pumped through a superheater and delivered to the boilers at a temperature near the boiling point.

By virtue of the increased temperature of the feed water thus obtained, it was found possible to shut down several of the existing boilers and yet maintain a satisfactory steam pressure, whereas, prior to this use of the exhaust steam there had been a continual shortage of steam even with every boiler forced to the limit. By an approximate rule for the conditions of ordinary practice, a saving of 1 per cent. is made for each increase of 11 degrees F. in the the temperature of the feed water, and according to this, the saving in fuel at this station is about 13 per cent., besides the saving in labour due to less fuel handling and boiler attendance.

The system as now in operation at the above mentioned works is shown diagrammatically in Fig. 1. At the left there is an 8-inch cast-iron receiver pipe *A*, which conveys the exhaust steam from the stationary engines, steam hammers, etc. Each engine and steam hammer has its exhaust pipe coupled to this receiver by means of a Y-connection *B*, having a 4-inch branch, which, by means of a reducer, can be coupled to any size of exhaust pipe.

At the blacksmith shop one of these receiver pipes runs the entire length of the building, outside of the wall, about a foot below the ground surface. This pipe has numerous connections from engines and hammers and discharges into the jet condenser *C*. Inside of this condenser there is a funnel-shaped plate with a center opening about 10 inches in diameter, just above the manhole. Jets of cold water are arranged to play upon this plate, condensing the steam as it comes in contact with both the plate and the cold water.

A few inches below the manhole a

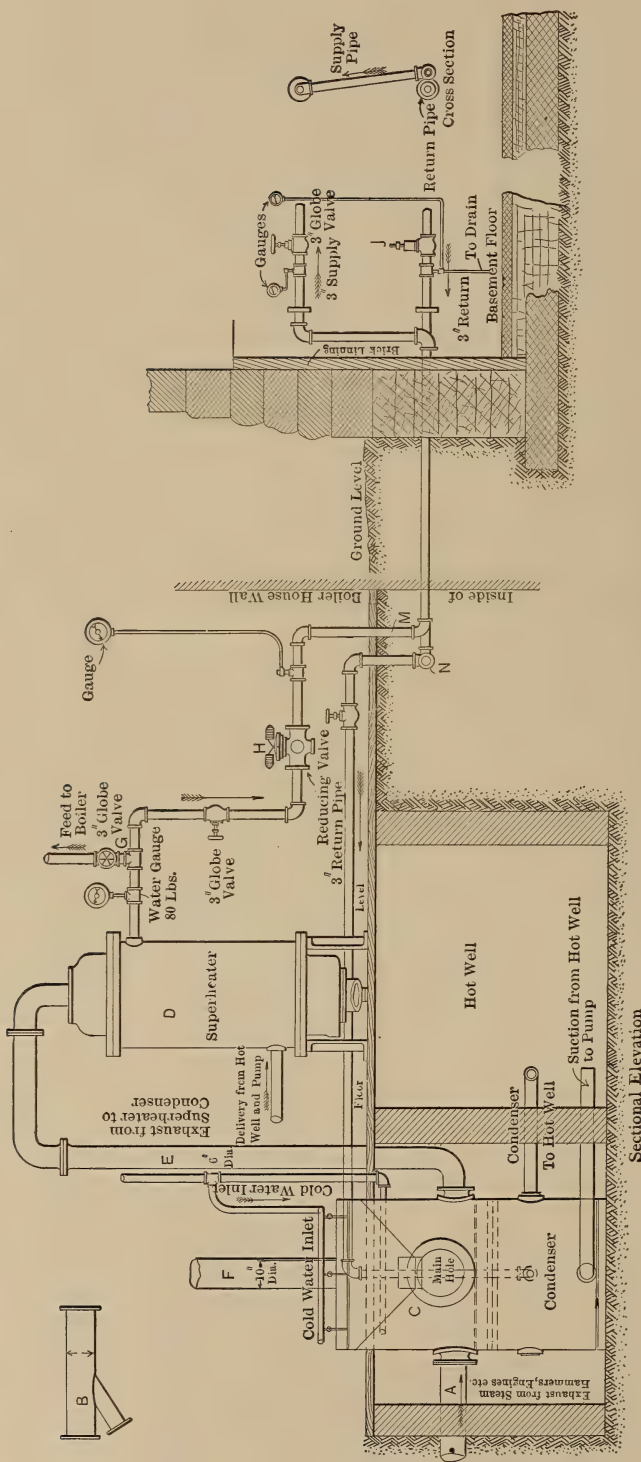


FIG. I.—GENERAL LAY-OUT OF EXHAUST STEAM UTILIZATION SYSTEM AT THE LOCOMOTIVE WORKS OF THE GRAND TRUNK RAILWAY, MONTREAL, CANADA

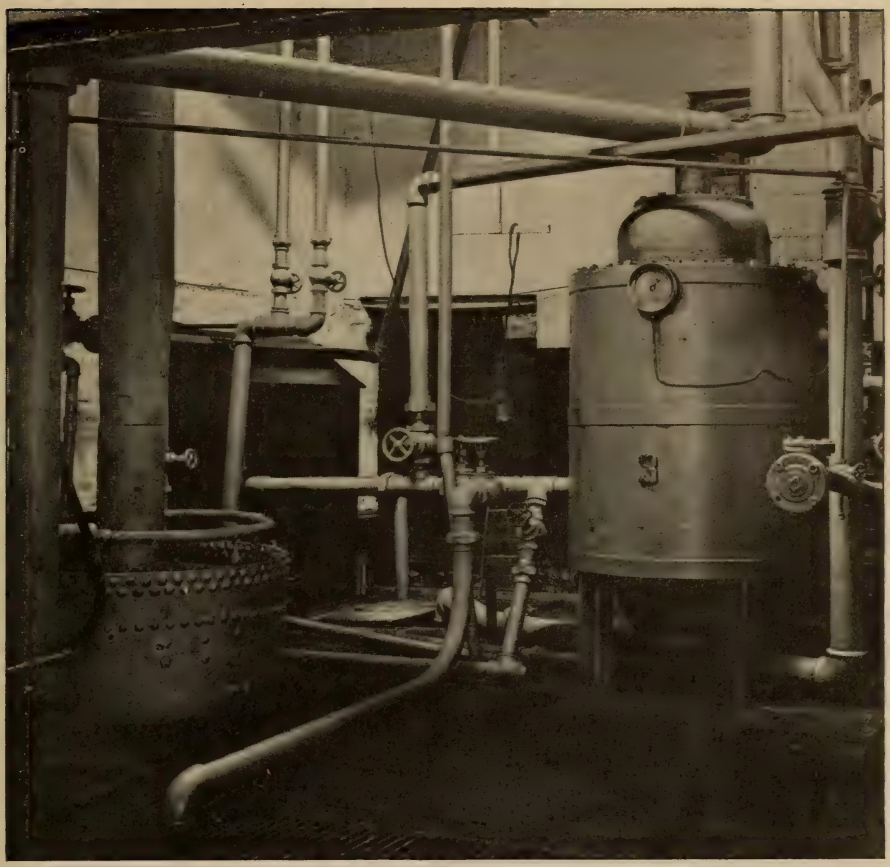


FIG. 2.—THE CONDENSER ROOM

circular angle-iron supports a bed of charcoal, carried on a perforated plate, the charcoal being covered with a fine copper mesh, which is cleaned off at regular intervals. This is for the purpose of separating impurities from the water of condensation, which then flows to the bottom of the condenser and thence to the hot well.

The exhaust from one of the large engines is passed in at the bottom of the superheater *D*, and thence goes to the condenser by the pipe *E*. The pump is set in a pit on a level with the bottom of the well, from which the water flows by gravity to the pump, and having, therefore, no suction duty to perform, its only function is to force the hot water through the superheater and thence to the boilers.

It frequently happens that the exhaust steam comes into the condenser in greater volume than it pays to condense it. A floating indicator in the well shows when the hot water is about to flow over and go to waste in the drain. The condensing water is then cut off, and the uncondensed steam is allowed to pass out at the top of the condenser to the atmosphere by means of the 10-inch galvanized bent *F*.

Aside from the economies effected by utilizing this waste steam which formerly escaped through various pipes in the shop roof, the trouble formerly experienced during the winter season, caused by icicles form-

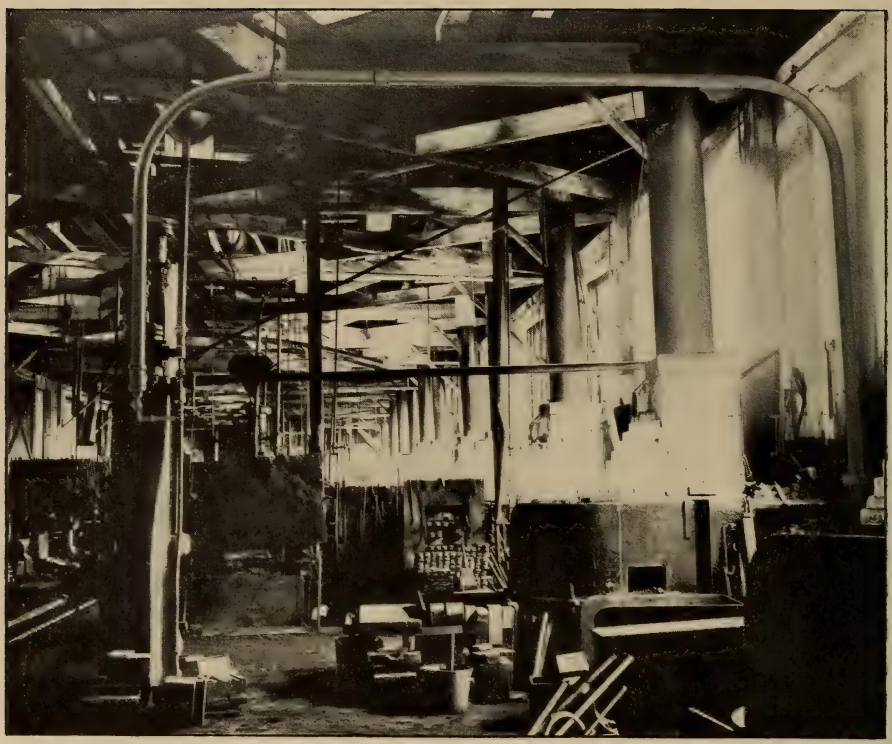


FIG. 3.—ARRANGEMENT OF EXHAUST PIPE OF ONE OF THE SHOP HAMMERS

ing along the eaves is to a large extent eliminated. These icicles obscured the light, and in falling were often the cause of broken windows. Since the disappearance of the exhaust steam also, the shop now presents a clean, tidy appearance externally. Furthermore, the receiver pipe being outside the shop wall, transmits heat to the ground, keeping it bare of snow, where previously there were large accumulations, and the water of the melted snow, sinking through the ground and reaching the receiver pipe, assists condensation.

It may here be remarked that when this utilization of the exhaust steam was first proposed it was apprehended that back pressure would interfere to a certain extent with the efficiency of the steam hammers, etc., but nearly four years' experience has demonstrated that these fears were groundless, and no difference in the working of the steam-driven machines due to this cause has been observable. There is indeed a slight tendency to a vacuum in the condenser, sufficient to cause a free flow of steam from the receiver to the condenser; but as the condenser has a 10-inch vent to the atmosphere, there can be no back pressure and very little vacuum.

Fig. 2 is a view of the condenser room, showing the condenser at the left and the superheater at the right; the hot well is directly underneath the superheater, and the movable grating on the floor covers the pit containing the hot-water pump.

Fig. 3 shows the exhaust pipe of a single-frame hammer, leading to the receiver pipe. There are eight single-frame hammers distributed along this shop, each one connected to the receiver pipe in this manner. This applies also to the exhausts from other steam-driven machinery

in this department. Fig. 5 is a view in the forging shop, which is a widened continuation of the blacksmith shop. Here there are four large double-frame hammers. It was found more convenient to deliver the exhaust into an overhead receiver pipe in this shop as shown. Fig 6 is another view of this shop, showing the receiver pipe dropping to the ground prior to delivering to the condenser.

HOT WATER FOR HEATING THE OFFICES

After the system which has just been described had been in operation for several months, it occurred to the writer that as there was such an abundance of hot water, it might advantageously be used for heating purposes, and after consideration it was decided to connect one of the hot feed-water pipes to the existing system of hot water radiators in the offices of the motive power department which had hitherto been heated by a furnace in the basement. This furnace consumed about 70 tons of anthracite coal annually, at $7 per ton. By dispensing with this furnace, the fuel item was eliminated, together with the labour incidental to handling the coal and ashes. The fire risk also was largely eliminated, as there is now no fire of any kind in the building.

The building measures 60 feet by 60 feet, and has four floors and a basement. It stands alone about 200 yards from the works.

The idea of forcing hot water for heating purposes is of course not new. In one such system, known as a closed system, the water is under pressure and is circulated by means of a centrifugal pump located in the line of pipe in a special fitting, this fitting being part of the pipe line. The system herewith described may be termed an open system, the hot water being taken from a well, whence by means of a pump it is circulated through the radiators. The details of this arrangement are practically as follows:—

The connection with the feed pipe

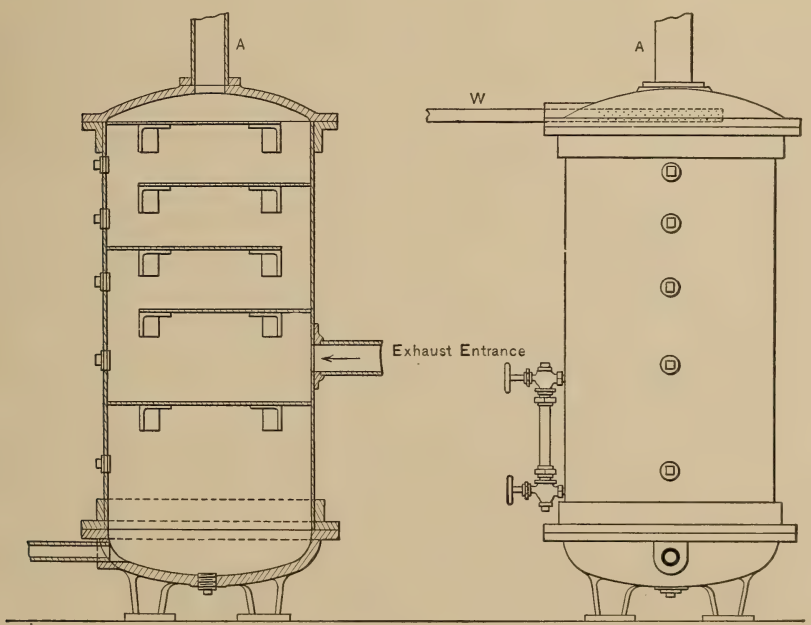


FIG. 4.—A SPRAY CONDENSER

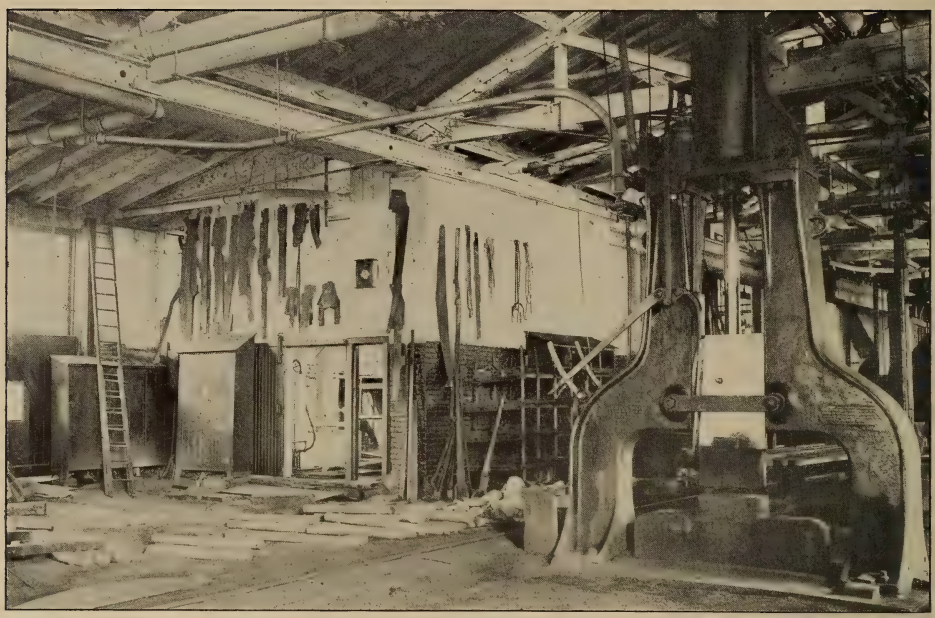


FIG. 5.—IN THE FORGE SHOP. THE EXHAUST IS DELIVERED INTO AN OVERHEAD RECEIVER PIPE

to the boilers is made by putting a T-fitting, *G*, Fig. 1, on that pipe, and beyond this is a reducing valve *H*. A 3-inch flow pipe *M*, and a 3-inch return pipe *N* are laid in a box about a foot below the surface of the ground. On the return pipe a valve *J* is placed to regulate the flow of the return water, the circulation of which requires to be faster when the temperature is low.

A retaining valve having a spring screwed down to resist a pressure of some fifteen pounds greater than the head of water in the building is put on the return pipe at a convenient point between the regulating valve and the condenser. The object of this retaining valve is to insure that the whole system shall be kept full and under proper pressure, thereby preventing the drawing in of air.

The results of this experiment were so satisfactory in every respect that it was decided to heat the Railroad Y. M. C. A. Building, which was then under construction, in a similar manner. This building is about 150 long by 50 feet wide, and is situated across the street from the motive power offices. It has three floors and a basement.

The heating system of this building is connected to the same 3-inch pipe that conveys the hot water to the motive power offices, but on entering the building the 3-inch pipe discharges into a 5-inch pipe. At about the center of the building this pipe rises vertically, carrying the water to the ceiling of the top floor, where it discharges into a 4-inch pipe. This pipe runs the entire length of the ceiling and has a number of $2\frac{1}{2}$ inch branches on either side which run to the side walls, dropping to the radiators on each floor, and finally discharge into the return pipe in the basement, whence the water is conveyed back to the condenser. An additional pump is installed on account of the increased duty. These pumps are so connected that if one of them should be under repairs the other will keep up the circulation of water throughout the heating system.

This arrangement also has given satisfactory service during the past

two severe winters. It differs somewhat from that of the motive power offices, where the water is forced upward through the radiators, it having been thought that the downward flow through the radiators would perhaps be better adapted for this forcing system, but experience has shown that both arrangements are equally satisfactory. In the absence of exhaust steam, as when the works are closed, the well is heated by live steam.

By the adoption of the plan of heating here described, the Railroad Y. M. C. A. was relieved of the expense of installing heating furnaces, and also the much greater expense of providing fuel for heating purposes.

The new Railroad Y. M. C. A. Building at Stratford, Ontario, is now similarly heated by exhaust steam from the works at that place. A large portion of the Montreal works is now also heated by this method, which is being adopted gradually throughout the Grand Trunk Railway system for work shops and round houses, with certain modifications to meet local conditions. Where the supply of exhaust steam is limited, the condenser is dispensed with.

Within the past two years five new roundhouses have been built at various points on the system, which are very satisfactorily heated in the following manner:—The exhausts from the stationary engine, air compressor and pump are passed through the superheater and thence direct into the hot well. The water is pumped through the superheater, and after circulating through the heating coils returns to the well. Steam

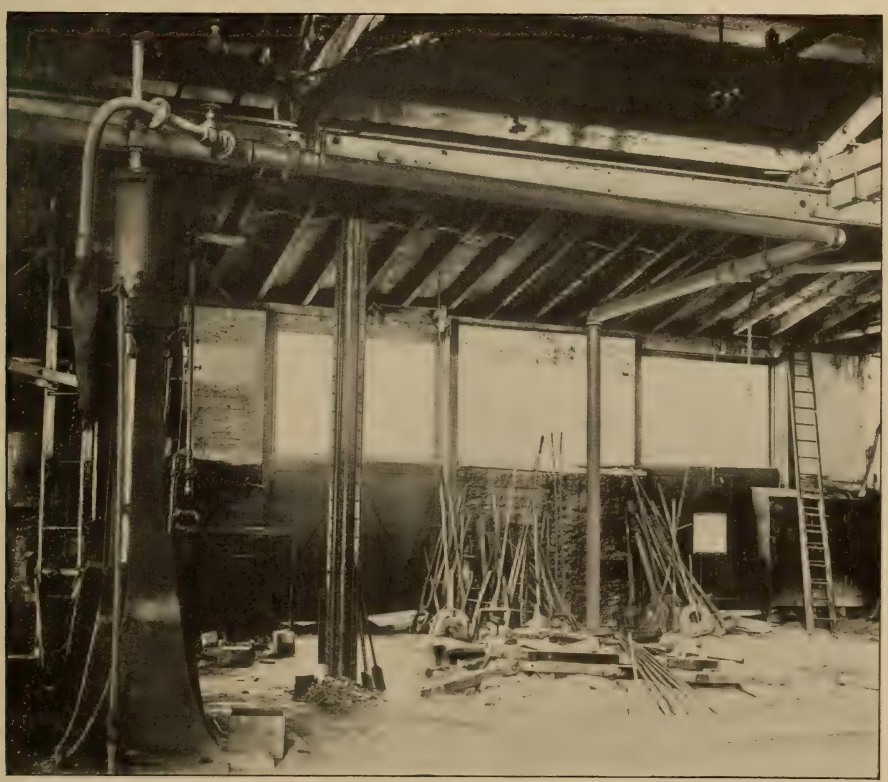


FIG. 6.—ANOTHER VIEW OF THE FORGE SHOP, SHOWING THE EXHAUST RECEIVER PIPE WHERE IT DESCENDS TO THE GROUND

blown from locomotives is discharged direct into the well.

A pipe of comparatively small size will suffice to carry the hot water to the building to be heated, but the pipe to which the branches are connected should be of such ample proportions as to insure that the branch at the furthest extremity will be properly fed; in other words, it should be considered as a reservoir to feed the branches. This is an important point.

In the winter season it is a difficult matter to keep roundhouses warm, on account of the necessarily large doors, which are frequently opened to permit of the entrance or exit of engines, yet by this method of heating, the temperature of these roundhouses is such that engines are soon thawed out, permitting of required repairs and cleaning without delay. In addition to this advantage, the whole roundhouse staff renders more efficient service than when working in discomfort, and the engineers and firemen are attracted to spend their spare time working about their engines, as is the custom with many during the summer, but which only the more faithful will do in a cold and draughty building.

At the Montreal works of this company there is a pumping station at the river bank for supplying water to the works, where formerly the feed water for the boilers was delivered at river temperature (32 degrees F. in winter). Since the installation of a spray condenser, shown at Fig. 4, a saving in fuel has been effected of about 17 per cent.

This spray condenser is 2 feet 3 inches in diameter by 4 feet 6 inches in height, and stands on the floor beside the boilers. A perforated pipe to deliver a spray of cold water *W* is inserted into the side of the condenser near the top, the water descending over four plates, forming partitions about 8 inches apart, each plate having an opening at one side so arranged that the water follows a zigzag course. Below these plates and a little below the center of the reservoir, the exhaust steam from the pump enters, and as it ascends between the plates, it is met and condensed by the descending water, with which it flows to the bottom through a perforated plate, from which point it is delivered to the boilers by a feed pump. There is a water gauge at the side of the condenser, and the flow of condensing water is regulated to keep the body of the water in the condenser below the entrance of the exhaust steam. A pipe *A* to the atmosphere permits of the escape of excess steam.

This arrangement has proven so satisfactory that authority has been given to have a similar device applied to road pumping stations, and when this has been done a station or any other building within a reasonable distance of the pump house may be heated by the boiler-feed pump in the manner already described.

THE SUCTION GAS PRODUCER

By W. H. Booth

AN account of the suction type of producer would hardly be complete without some reference to early producers from which the suction producer took its rise. The earliest producer,—that of Kidd & Barff,—was a small cylindrical vessel, the inside casing of which was a coil of pipe, a central space being left for the fuel, which was broken anthracite. Below was a grate and enclosed ashpit; a coal-charging box and a steam-worked air injector completed the apparatus. External to the producer was a pressure vessel into which water was forced by a pump. This vessel fed a limited quantity of water through the pipe coil and produced superheated steam, which, by means of the air it injected, operated the producer. Mr. Dowson modified the plant by using a separate boiler.

It was Benoit, a Frenchman, who realized that the engine might be made to draw its own gas and thus to operate a producer without a steam jet. But a little water was allowed to drip upon the fuel so as to produce steam, which, becoming dissociated, kept up the high thermal value of the gas. Later came the attempts to use bituminous fuel. To do this, Thwaite employed a duplex producer consisting of two side-by-side vessels joined by a top neck. The vessels were fed with coal alternately and air was blown into the base of each vessel in turn. The green fuel gave off its volatile gases and these had always to pass down the full depth of the freshly blown fuel in one producer while the other was again being blown into activity. An automatic change valve effected the periodical reversal.

Though before its time, this duplex plant forms a basis for perhaps the near-future generator which will use ordinary coal. Then came the recognition of the blast furnace as a gas producer, due to Thwaite also. Though, strangely enough, very little has been done in Great Britain with blast-furnace gas, it is to this that gas engines owe their growth, and that gas power has become established on its present secure basis. Thwaite proved that the existing idea of producer gas as of necessity of high thermal power was wrong. Blast-furnace gas well below 100 B. T. U. per cubic foot was shown to ignite readily, and one realized the effect of compression in causing easier ignition and also that hydrogen beyond 3 to 5 per cent. was too much for the high compression on which the economical working of the gas engine depended.

The suction gas producer is the very natural outcome of a desire to simplify the production of power by simplifying the plant. Regarded by some merely as a passing phase of the gas producer generally, it is esteemed by others as offering a ready solution of at least the question of small power production.

The gas engine has made rapid strides in late years, especially in respect of the reduction of its dimensions for a given power. The single-acting 4-cycle engine has many obvious disadvantages. Being single-acting, it must necessarily possess a cylinder at least 41 per cent. larger in diameter than a double-acting engine of the same power. The reduced size of cylinder carries with it reduced dimensions all round, while the double-acting principle still further reduces the stresses, or the potential effect of the stresses, in the

crankshaft which is so important a member and, in single-acting engines, has been exposed to reversed stresses of a severe order.

Thus in making an engine double-acting its frictional losses should be reduced to less than one-half, or if the single-acting engine indicating 100 H. P. gives off 75 B. H. P., the double-acting engine should give 87½ B. H. P., and therefore the cylinder volumes, in place of having the ratio 1:2, might be expected to have a ratio of 1:2.33, or a diameter ratio of 1:1.52. Gas is drawn into the cylinder twice as frequently, though in less volumes at each draught for an equal total power. The draught of gas is, therefore, much more regular, and this is an advantage for the suction producer, the action of which, though indicated by its name, may be briefly explained.

A suction gas producer is simply one through which air and, if employed, steam are compelled to travel by reason of the fact that the running of the gas engine itself supplies the motive power. The gas pipe to the engine comes directly from the producer, and when the piston moves out and draws in its charge of air and gas, a partial vacuum is produced in the gas pipes, which can be made good only by the entry of air through the producer. Nothing could be more simple in idea if carried out in a satisfactory manner.

Producer gas is mainly carbonic oxide, *CO*, a gas possessing toxic properties. It is a peculiar gas, in that while it will not support life, it is also poisonous, unlike carbon dioxide, which, though a non-supporter of life, has no active toxic property, but is merely neutral, like nitrogen. The poisonous quality of carbonic oxide makes it necessary that suitable precautions should be taken as to leakage and that provision should be made for satisfactory ventilation when installing gas producers. With the suction producer there is at least

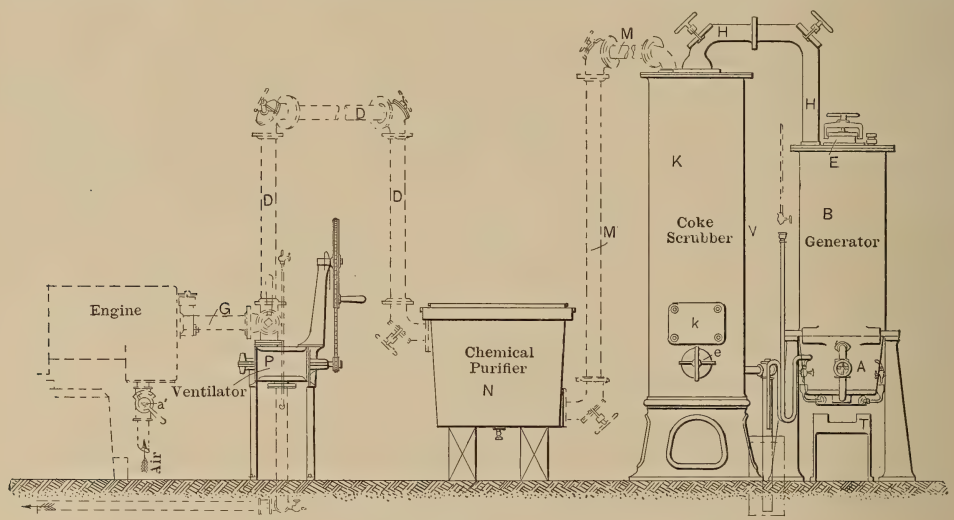


FIG. 1.—SUCTION GAS PLANT MADE BY MESSRS. J. & G. O. PIERSON, PARIS

the fact that, while the engine is running, there is a pressure within the producer less than that of the atmosphere, and all leakage therefore must be from without, inwards.

Carbonic oxide is very greedy of oxygen, and probably owes its toxic property to this. Since the pressure inside a suction gas producer is slightly less than that of the external atmosphere, and there can be no

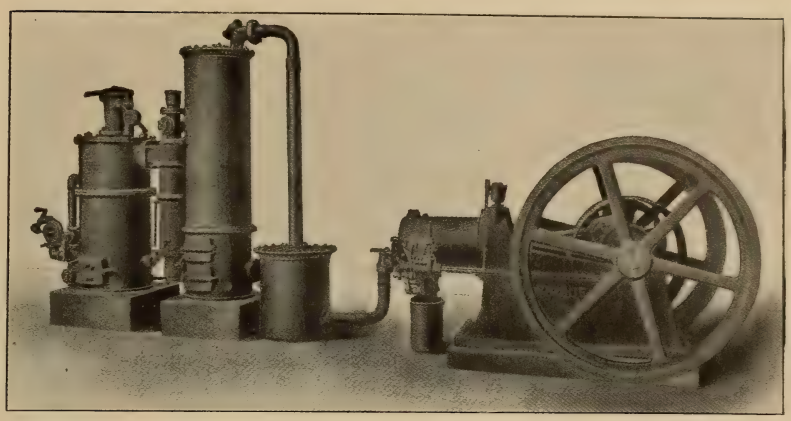


FIG. 2 —SUCTION PRODUCER MADE BY THE DUDBRIDGE IRONWORKS, LTD., STROUD, ENGLAND

pressure tendency for the gas to escape into the room, this is properly claimed as an advantage of this type of producer, the risk of leakage being minimized. But a gas producer cannot supply gas to an engine until it is fully alight. Means must be taken to light up a producer and set it going before the engine can be started and made to furnish the necessary motive power for the continued action of the producer. A very usual system is to blow air into the producer by means of a fan, a valve being opened to allow the gas to escape to a chimney. During this operation there is a pressure in the producer slightly greater than that of the atmosphere.

This has perhaps the disadvantage of causing gas leakage outwards, but it has the advantage that the gas will travel towards the engine, which may thus be more readily started than when the engine requires to draw out of the pipes any air and gas of too poor a quality to ignite in the cylinder. Or the gas producer may be connected to a chimney and to the engine supply pipe by a three-way cock or by interlocked shut-off cocks, so connected that one must be open while the other is shut. The producer is started by aid of the chimney draught, being simply lighted up with a little greasy waste or wood until sufficiently hot, when the engine valve may be opened, the chimney valve closed, and the engine started.

As regards the general principle of the suction producer, this in no way differs from that of all other producers. Assuming for simplicity of calculation that the fuel used is pure carbon, the heat value of which per pound is 14,647 B. T. U., the production of the first oxide of carbon, CO generates 10,232 B. T. U., of which 5871 are rendered latent in converting the solid carbon into gaseous form, and 4415 B. T. U. are set free. When carbon undergoes its second step in oxidation, from carbonic oxide, CO, to carbonic acid or carbon dioxide, CO_2, 10,232 additional B. T. U. are generated, making, with the surplus of the first oxidation, $10{,}232 + 4415 = 14{,}647$ as above.

The object of a gas producer is to produce carbonic oxide free from carbon dioxide. The produced gas, when cooled, will, therefore, contain a calorific potential of fully two-thirds the original calorific capacity of the carbon. The 4415 B. T. U. are thus wasted entirely so far. In practice, however, the limited height of gas producers and the want of homogeneity of the charge of fuel make it impossible entirely to prevent the formation of CO_2, and the escaping gas is even hotter than

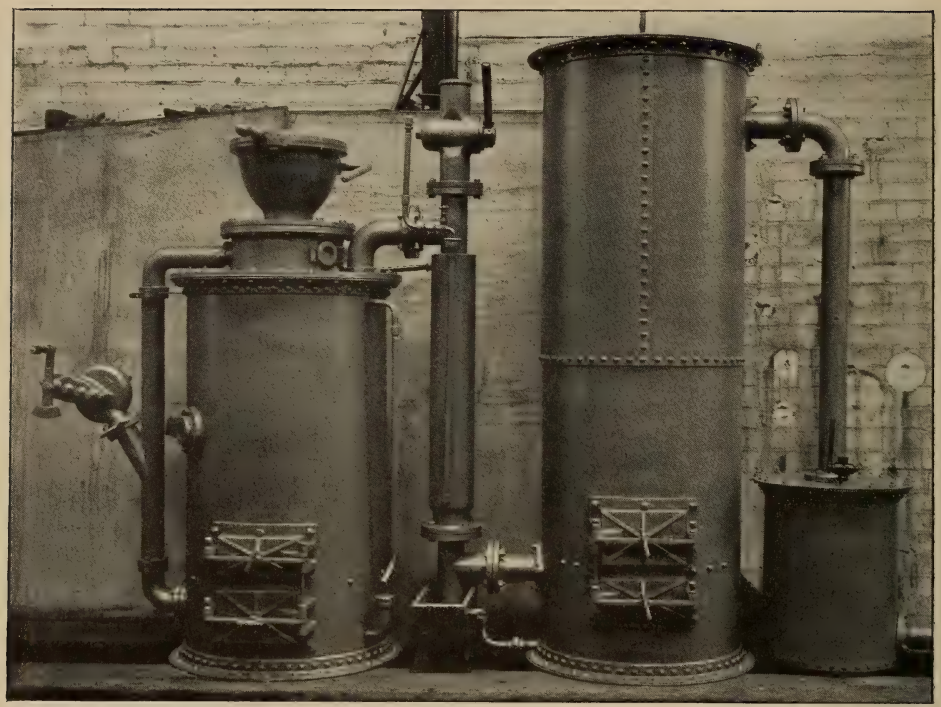


FIG. 3.—SUCTION PRODUCER PLANT MADE BY MESSRS. T. H. & J. DANIELS, LTD., STROUD

it would be under other conditions.

It is a property of red-hot carbon that it possesses the power of decomposing steam when brought into contact with it. This action may be thus represented,—

$$C + H_2O = CO + 2H,$$

Hydrogen gas and carbonic oxide are produced as a result of this reaction. In the so-called dry working of a producer, the whole of the oxygen is supplied from the air, and, for every 21 volumes of oxygen 79 volumes of nitrogen are introduced. Dry producer gas may be represented thus:—$C+O+3.8\,N=5.8$ volumes of gas of which only 2 volumes are combustible oxide, or less than 35 per cent.

If, however, in place of using so much air, a mixture of air and steam be employed, the final gas will contain carbonic oxide and hydrogen and nitrogen, but the hydrogen and some of the carbonic oxide will now come from the decomposition of the steam, and the proportion of nitrogen will be reduced. The steam is produced by a boiler arranged within the gas producer to utilize the 4415 B. T. U. that go to waste in the gas producer. To split up a pound of steam into its constituents requires energy to the amount of 6900 B. T. U. This energy has to be given up by the red-hot fuel, and each pound of steam produces one-ninth of a pound of hydrogen, which hydrogen adds 6900 heat units to the capacity of the final gas mixture.

The oxygen, set free by the decomposition, promptly unites with the carbon and produces 4415 heat units per pound of carbon. As there are 8-9 pound of oxygen from each pound of steam, there will be required $\frac{2}{3}$ pound of carbon to carbonize the oxygen and the actual heat produced will be $\frac{2}{3} \times 4415 = 2943$ B. T. U. For each pound of steam decomposed there will, therefore, disappear $6900 - 2943 = 3957$ B. T.

U. Obviously, therefore, if steam alone were turned into a producer full of red-hot carbon, there would be a rapid absorption of heat and the carbon would be cooled and soon extinguished. In practice, consequently, the amount of air must bear such a ratio to the amount of steam that the process of gas making shall be continuous. If the steam producer or boiler be heated by the producer, any excessive production of steam would so cool the producer that the production of steam ficed by the increased production of CO_2.

When oxygen meets red-hot carbon, the carbon is at first converted to CO_2. It is only by the presentation of more hot carbon that this CO_2 is turned into combustible CO, but some of the CO_2 always gets through unconverted. A small percentage of hydrogen gas is of advantage, owing to its aid in propagating flame, but if too much hydrogen be added, there is danger of pre-ignition; a gas rich in hydrogen will not bear

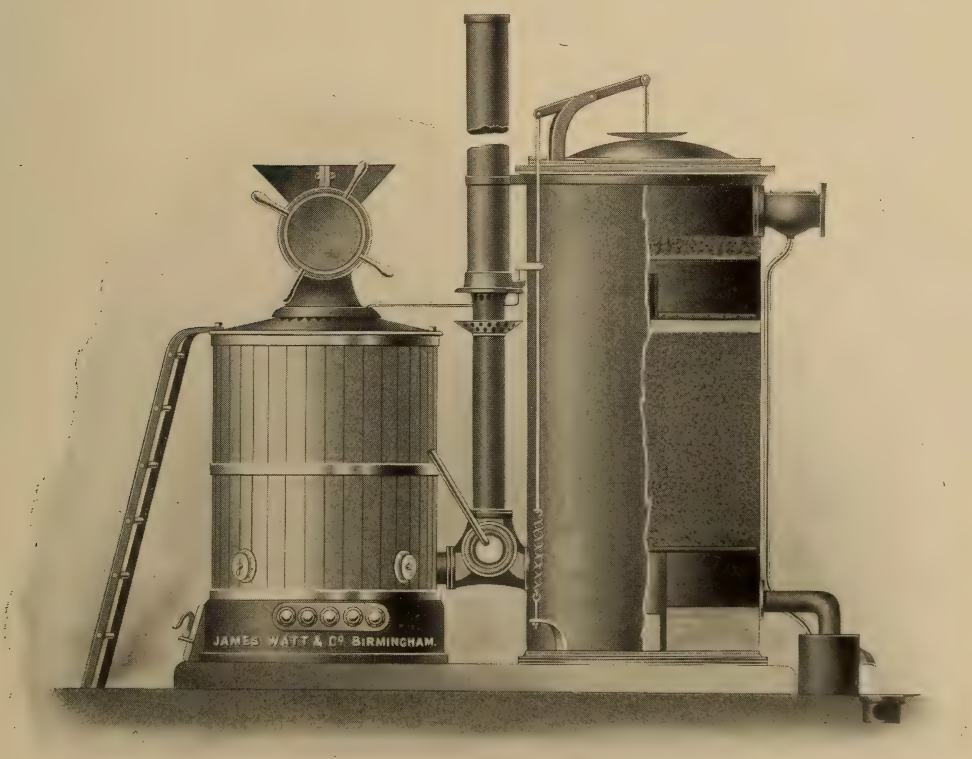


FIG. 4.—A SUCTION PRODUCER MADE BY MESSRS. JAMES WATT & CO., BIRMINGHAM

would speedily be reduced. The action is, therefore, automatically controlled.

The addition of hydrogen and the concomitant reduction of nitrogen produce a much more powerful gas, but a part of the advantage is sacrificed by the same heavy degree of compression as a gas more purely of carbonic oxide make-up. This was early pointed out by B. H. Thwaite in connection with blast-furnace gas, in the use of which he was the pioneer. Such then are the general

principles of the suction producer. In what follows will be found how these principles have been adopted in practice and how far practice has been adapted to coincide with principles.

It may be added that the favourite fuel for gas producers is anthracite coal. Being free from hydrogen, it makes no tar to cause trouble in the gas engine. It burns without caking and cannot set itself into caves or arches in the producer. Unlike coke, which is very light and rough on the surface, its weight causes it to settle down in the producer, thereby packing fairly solid and reducing the chance of any CO_2 escaping as CO_2 unconverted to CO.

Bituminous fuel has always proved more difficult to use. It produces so much tarry matter that this must be split up into gas, an operation that makes it necessary to supply the air at the top of the producer so that the gas must pass down and through the incandescent fuel, as described previously in speaking of the Thwaite duplex producer.

The grate is a matter also on which much designing ability may be spent. Some producers have grates. Others possess no grates, the fuel simply resting on a heap of ashes and clinkers in the water bottom of the producer. The ashes are raked out through a water seal, as required, lowering the fuel then deprived of support.

Some producers have a similar ar-

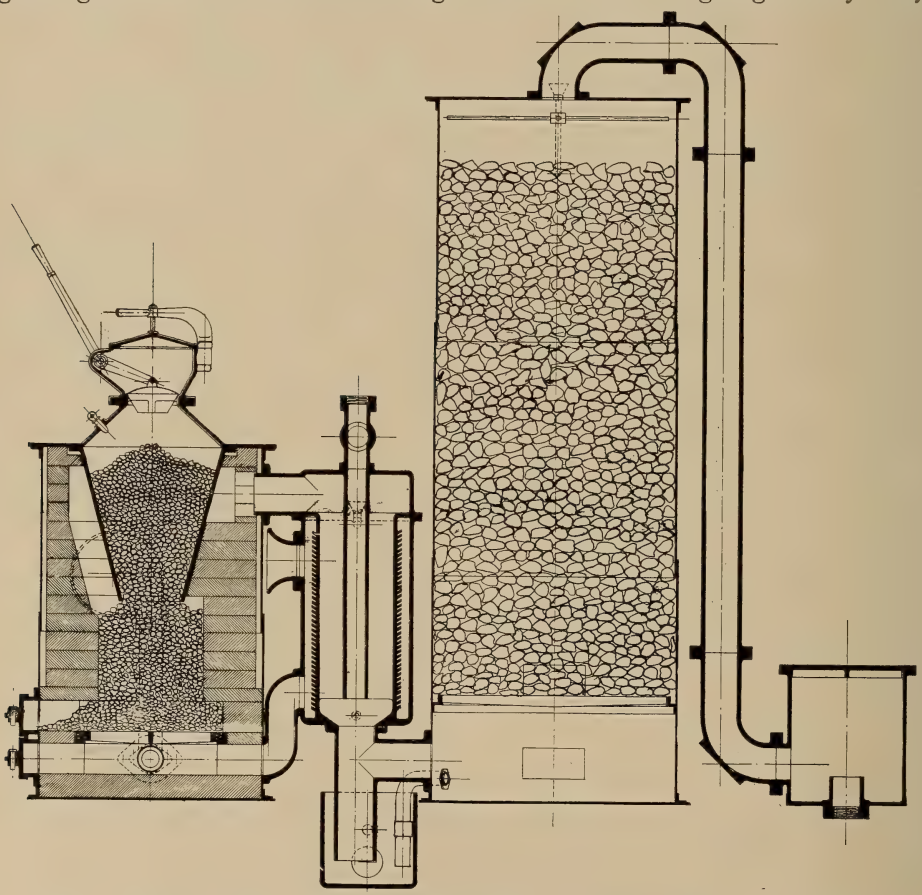


FIG. 5.—VERTICAL SECTION OF THE PRODUCER MADE BY THE KYNOCH COMPANY, BIRMINGHAM

rangement, but open to the air, the fuel resting on a plate placed a few inches below the bottom of the producer. As ashes gradually accumulate they are removed, and the fuel in the producer is allowed to fall towards the bare plate. Air enters at the free opening and steam from the vapourizer is also brought down to this point.

An example of this type of producer is that shown in Fig. 1, and made by J. & G. O. Pierson, of Paris. Here a gas generator vessel *B* is fed with fuel by the throat piece *E*. Around the base is a water vessel *A* exposed to the full heat of the fuel and not lined with firebrick. No adhesion of clinker can thus occur. The fuel rests on a firebrick plate *T*, and coal as small as $\frac{1}{4}$ inch or $\frac{1}{2}$ inch may be employed, and has, it is said, been used successfully even with an ash contents as high as 28 per cent. The gas passes by the pipe *H* to the base of the scrubber, up which it rises through a coke filling, and passes off by the pipe *M* to a purifier *N*, and so on by the pipe *D* to the engine. The fan or starting exhauster *P* is, it will be noticed, close to the engine, thus ensuring that the pipes and purifier and scrubber shall become filled with good gas, leaving only the pipe *G* to be emptied of air when the engine is started. When tested, the pressure in the producer was one-tenth of an inch below atmosphere. Before the purifier it was $\frac{1}{2}$ inch and at the engine $\frac{3}{4}$ inch of water gauge.

The makers state that the plant may be run for a week without stoppage, and that the gas will give a mean pressure in the cylinder of about 85 pounds per square inch. The consumption of actual coal per actual horse-power has been as low as 1 pound per hour.

This producer is singular in the disposition of the water of the vapourizer around the base of the producer. It is claimed to be more regular in action than when placed above. Being water-cooled, the clinkers do not adhere to the wall of the lower part of the producer as they do at the hot zones of other producers, and it is claimed that the firebrick lining requires less repair and that the labour of removing clinker is avoided. The upper part of the producer is large enough to hold 10 to 12 hours' demand of fuel.

In the Dudbridge producer, Fig. 2, of the Dudbridge Iron Works, Ltd., of Stroud, England, the steam is produced in a vessel which forms an annular chamber around the gas inlet valve. The lower half of the chamber is filled with water, while air enters by a ring of holes, sweeps before it the vapour and passes thus vapour-laden to the gas producer. There is the usual coke scrubber common to all producers.

Messrs. T. H. & J. Daniels, Ltd., also of Stroud, are makers of a very similar plant, and give the floor space for a 16 B. H. P. installation as 11 feet by 2 feet 9 inches; for a 25-H. P. plant as 11 feet 6 inches by 3 feet; for a 60-H. P., as 16 feet by 4 feet, and for a 100-H. P., as 21 feet by 4 feet 6 inches, the fuel being small anthracite or small broken coke. They estimate that with a fuel consumption of 1 pound per B. H. P.-hour, the cost is about the same as if town or lighting gas were available at 6d. per 1000 feet,—perhaps 8d. These producers have fire grates and a hand fan for starting as arranged in Fig. 3.

In Fig. 4 is shown the suction producer of James Watt & Co., of Birmingham, which is an example of a producer to which a draught chimney is applied, instead of a fan, with a three-way change cock to allow the chimney to act when required. In this producer there is a grate with rotating and withdrawable firebars. The construction of the scrubber is visible in the illustration, a special feature being the flexible diaphragm top cover which, acting like the usual gas bag, allows a full supply to pass to the engine at the same time as it steadies the pull on the producer.

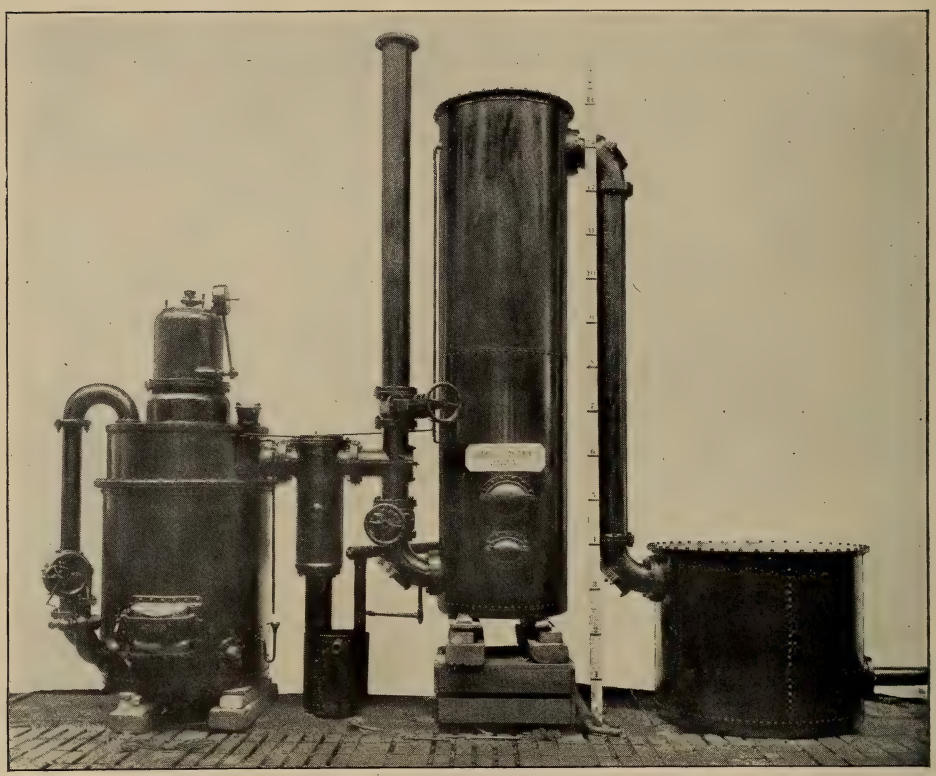


FIG. 6.—A 120-H. P. SUCTION PRODUCER PLANT MADE BY THE CAMPBELL GAS ENGINE CO , LTD., HALIFAX, ENGLAND

The waste heat of the outgoing gas produces all the vapour required, the water vessel being within the producer casing.

Another Birmingham producer is that of the Kynoch Company, Ltd., Fig. 5. The Kynoch-Forward gas plant consists of a generator, a vapourizer of the external type, a scrubber, and an expansion box. An interesting point about this plant is the vapourizer, which contains only water enough to make steam as required, the quantity of water passed through the vapourizer being regulated by a special device operated by the suction of the engine.

The amount of steam can thus be regulated so as to prevent clinkering and yet so as not to make the gas too rich in hydrogen, which may cause pre-ignition of the charge. The air also is heated in the vapourizer and passes with the steam through the grate. The fuel is contained in a conical hopper at the top of the generator around which the effluent gas passes, thus heating the fuel before it reaches the incandescent zone. A fan enables the producer to be started quickly, a plant of this design having been started from a cold state in 12 minutes. The hopper is arranged so that the generator can be charged without admitting air.

To return a moment to the vapourizer, this consists of a shell of iron surrounding the passage along which the effluent gas must travel toward the scrubber. On the water side of this shell are a series of up-pointing projections or encircling ribs which will hold water. Water is admitted in measured quantity to the upper rib and overflows the whole of them in series, evaporating

completely before it reaches the lower rib. The advantage claimed for this system of regulated water supply is that when a plant is wanted in a hurry there is no great mass of water to be heated up, but as soon as gas begins to flow through the vapourizer, steam is produced for use in the producer.

The producer shown in Figs. 6 and 7 is that of the Campbell Gas Engine Co., of Halifax. The cuts are self-explanatory and show the starting fan, the vapourizer encircling the effluent gas passage with air inlet to vapourizer, and outlet to grate. A water seal in the base of the scrubber prevents reflux of the gas from this, so that there is always a body of good gas for starting the engine and held up close to this. The gas box placed near to, but after, the scrubber, is there for the purpose of providing a reasonable volume of gas, so as to moderate by its elasticity the fluctuations caused by the intermittent pull of the engine. This gas box is a common adjunct to all suction producers. It is seen in Fig. 8, which is a view of a producer made by Messrs. R. D. Wood & Co., of Philadelphia, who state as their opinion that failures in suction producers have been largely due to insufficient dimensions. With suitable proportions they guarantee to develop 10,000 B. T. U. per pound of Pennsylvania anthracite pea coal gasified in the producer, which would be the equivalent of 80 cubic feet of 125 B. T. U. gas, or of 70 cubic feet of 143 B. T. U. gas; but it is from the 10,000 B. T. U. that all calculations are based, so that if an engine requires 12,500 B. T. U. per B. H. P.-hour, the combined economy of such a plant will be 1¼ pounds of coal per B. H. P.-hour, while if this engine required 15,000 B. T. U. at one-half load, the combined economy would represent 1½ pounds of coal.

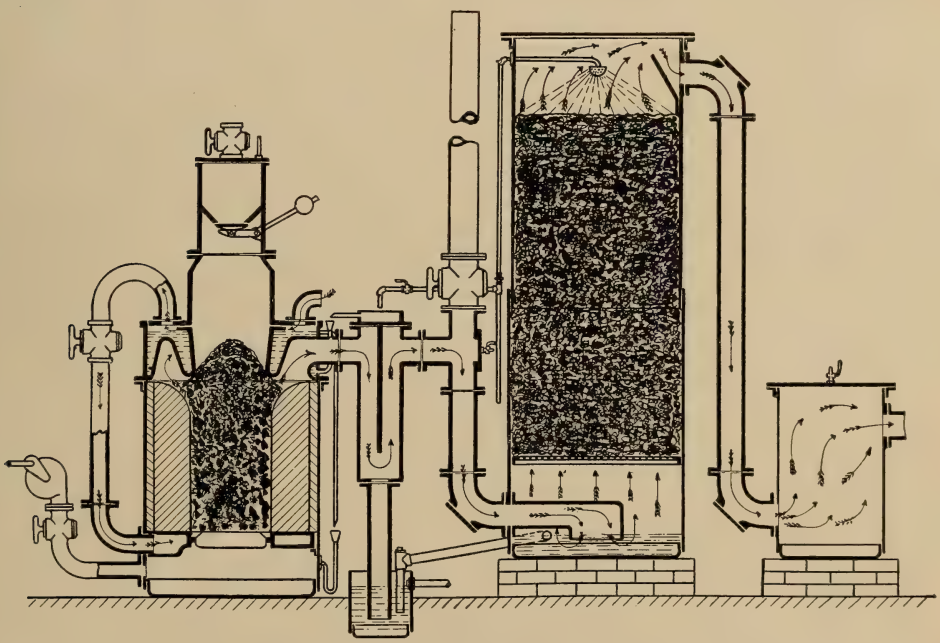


FIG. 7.—SECTIONAL ELEVATION OF THE CAMPBELL SUCTION PRODUCER

The figures on page 425 are offered by this firm as a basis of comparison for users of power.

From the above it is evident that the suction gas producer system should continue to grow in favour

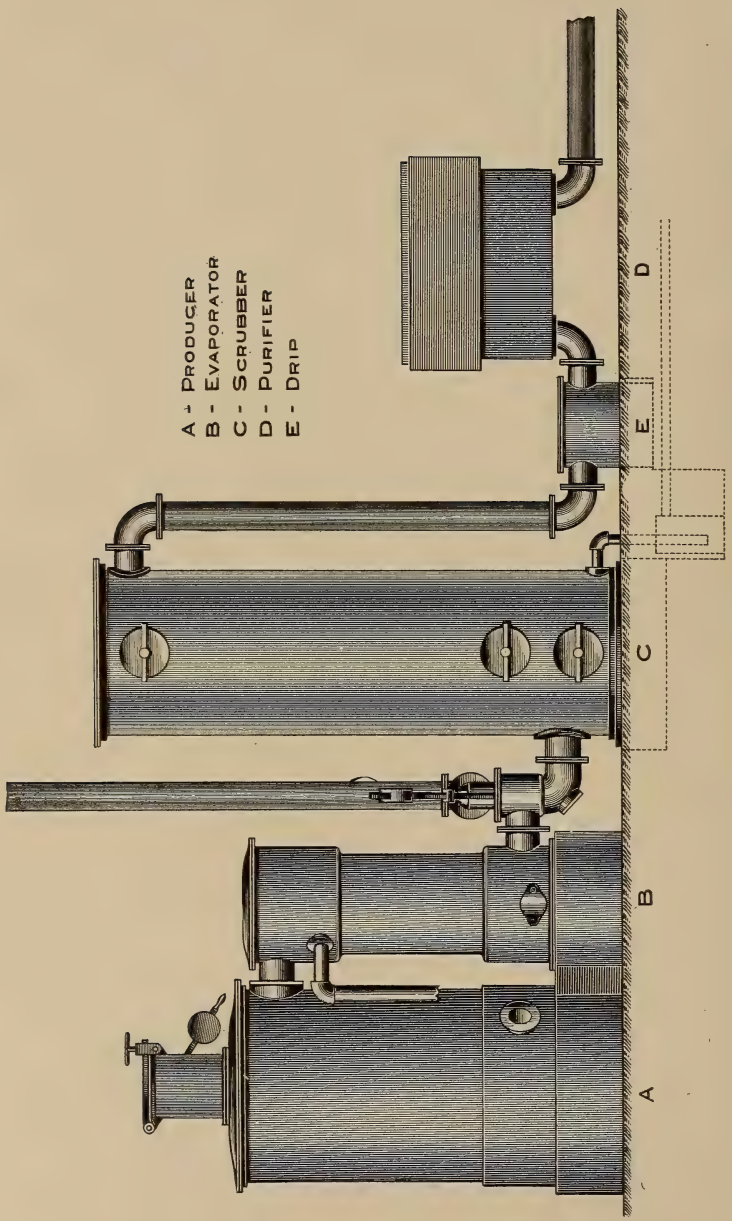


FIG. 8.—SUCTION PRODUCER GAS POWER PLANT FOR ANTHRACITE OR CARBONISED FUELS. MADE BY MESSRS. R. D. WOOD & CO., PHILADELPHIA

Type of engine.	Cost of fuel.	Consumption per B.H.P.hr.	Cost of 150 H.P. per yr. of 300 dys. @ 10 hrs.
Gasoline	6d gall.	0.104 gallon	£1125
Illuminating gas	3/1 per M.	18 cu. ft.	1200
Natural gas	1/1 " M.	13 cu. ft.	295
Simple steam	10/- coal	8 lb.	900
Non condensing compound steam	10/- "	5 "	560
Triple expansion condensing steam	10/- "	2 "	225
Suction gas producer - anthracite coal	18/- "	1¼ "	169

and general use, since if properly understood and installed, a consumption of 1¼ pounds of coal per B. H. P.-hour can be obtained on units as small as 25 H. P., in which small size it would be absolutely impossible to install steam plants to give the economies as per the table above.

Another American producer, Fig. 9, that of Dr. Oskar Nagel, of New York, is but another example of the very close resemblance between European, British, and American producers. Indeed it is difficult to see how these producers can depart far from a standard form. The plant illustrated is working in the machine shop of F. W. Hurstman & Co., at Newark, N. J., and produces 1 B. H. P.-hour from 1¼ pounds of pea anthracite and from 1½ pounds when on only half-load. For a plant of 20 H. P. this is a very good fuel record, as compared with what could be done with steam, and whereas steam would demand the whole attention of a man to take care of the water level in the boiler, if not of the engine, a suction gas plant can be loaded up with fuel and safely left to run. If the worst happens, the engine simply stops running. The scrubbers used in America are also coke-filled and water-sprayed, as in Europe. In brief, there is really little difference, if any.

Dr. Nagel claims that 80 per cent. of the heat value of the fuel will be found in the gas, that is to say, that a coal of, say, 14,000 B. T. U. calorific capacity will produce a gas which contains 11,200 B. T. U. The Dowson Gas Company, of Westminster, go so far as to claim an efficiency of even 89 per cent, or in other words, only 11 per cent. of the heat value of the fuel—ordinary commercial anthracite—was lost in the producer by radiation and in the gas which had to be cooled on its way to the engine. This can be attributed only to the absorption of the waste heat of the first oxidation of carbon by the water in the vapourizer and by the dissociation of the vapour by the hot fuel as already explained. When the producer is fed with fuel of regular size and is working well and not producing much or any CO_2, such efficiencies may perhaps be secured, but they should not be counted upon. A dry producer can theoretically give barely 70 per cent. calorific efficiency.

A brief inquiry may be made into the possibility of the further 19 per cent. of efficiency. The temperature of combustion of carbon to carbonic oxide, when air is the source of the oxygen, is 2705 degrees F. Let it be supposed that this is reduced to one-half, or 1352.5 degrees. Then there will have been used in the steam dissociation one-half of 4415 B. T. U. or 2207.5 units, which is just over 15 per cent. of the calorific value of pure carbon. The total percentage of efficiency thus calculates at 85 per cent. on the above basis.

Then a very small volume of CO_2 would account for a reduced efficiency, though certainly CO_2 may be fairly well compensated for by greater production of steam and consequently of hydrogen. There is also, it may be added, every justification for asserting that the carbon fuel fed to the producer acquires from the waste gases a considerable temperature, so that the actual temperature of formation of gas is 2705 degrees F. plus the temperature added by the waste gas. If this is, say, 440 degrees F., then it will represent an addition of a fourth to the 1352.5 degrees of temperature saved which, as shown, represent fully 15 per cent. of the fuel calorific capac-

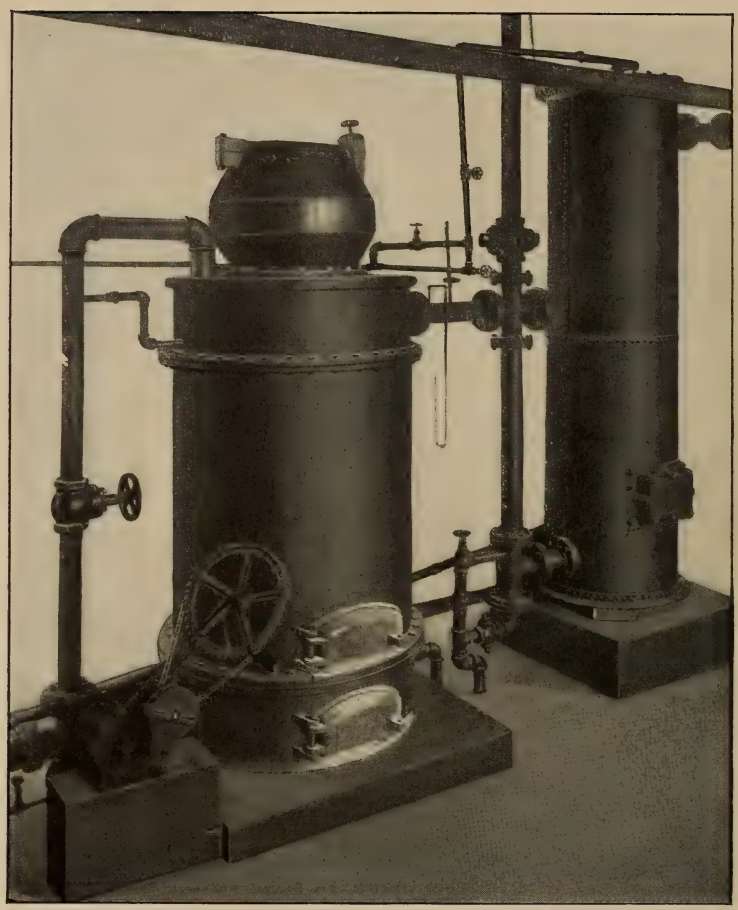


FIG. 9.—A PRODUCER MADE BY DR. OSKAR NAGEL, NEW YORK

ity. Thus to the already found efficiency of 85 per cent. there might be added a further $3\frac{3}{4}$ per cent., bringing up the total efficiency to $88\frac{3}{4}$ per cent., and the now missing one-quarter of 1 per cent. could be explained away on the ground that the dissociated oxygen would combine with carbon and produce a higher temperature than 2705 degrees obtainable on an air basis. Thus, under favourable conditions an efficiency of 89 per cent. is possible and serves to account probably for occasional unusually good fuel consumption figures. But more than 80 per cent. should scarcely be taken as a basis of design.

To be concluded in the April number

THE FUTURE OF THE AUTOMOBILE

TENDENCIES IN AMERICAN PRACTICE

By Winthrop E. Scarritt, Past President of the Automobile Club of America

THE two automobile shows held in New York City last January demonstrated conclusively that the American car is settling down to certain fixed types. Formerly in America the large single-cylinder car was very much in evidence, but the recent shows furnished only a very few examples of this class.

The American car to-day closely follows the general lines of the French automobile. It is a well-known fact that the so-called gasoline car, or internal combustion motor, has almost displaced the steam type. There is only one steam car on the American market that has demonstrated its practicability. In gasoline automobiles, multiple cylinders are the rule. There are makers who are beginning to manufacture even six-cylinder cars, and these are found to be quite successful. The shaft-driven car is also largely taking the place of the chain drive. Formerly, it was thought that the shaft drive could not be used for the large car, but the success of the shaft-driven cars more recently has demonstrated the fallacy of this idea.

While there are some successful air-cooled motors, the majority of the leading American manufacturers cling to the water-cooled engine. It is doubtful whether a high-powered motor can be successfully cooled without the use of the circulating water system.

The pressed steel frame is used almost universally, and those who still cling to the wooden frame have strengthened it by steel plates. Heretofore, the steel which has gone into the construction of American cars has not been equal to the German and French material. Recently, an important move was taken, however, by the American Association of Automobile Manufacturers, in appointing an engineer to act in conjunction with an engineer of the Bethlehem Steel Co., of Bethlehem, Pa., in making a careful study of the kind of steel best adapted to automobiles. The importance of this move cannot be overestimated. The company just mentioned is now successfully making steel which is the equal of any to be found elsewhere.

A marked tendency in the design

of the automobiles seen at the recent shows is towards the elimination of "trappy" piping, and the simplification of the car in all its parts. Another strongly developed tendency is to decrease the weight of the car and increase the engine power. Where formerly 10, 12, 18 and 24 H. P. were used for the average touring car, we now see 24, 35, 40, and occasionally as high as 60 H. P. It is a grave question whether we are not swinging to the other extreme of too great horse-power. One reason for engines of such high power is that the operator may take hills comfortably, and that he may drive through crowded city streets on the high gear, controlling the speed entirely by the throttle.

Another tendency is to make the cars of greater strength, and of longer wheel base. It is also a question whether we are not going to the extreme in this matter as well. While a car with a long wheel base rides more easily and comfortably, it is much more difficult to handle, especially in turning around.

The principal criticism which has been made of American cars heretofore,—in fact I do not confine this statement to American cars alone,—is that they are unreliable. The idiosyncrasies of the gas engine are well known. It sometimes takes an expert an hour to discover a slight trouble, which when found may be remedied in 5 minutes. Through better material, better workmanship, and close attention to details and adjustment, the motor cars have become far more reliable than they were two years ago. It is now an exception to see an automobile laid up on the highway for anything except tire troubles, and even these are far less frequent than they were formerly. This comes about through two facts,—the tire makers are putting better material into their products, and the manufacturers of automobiles are insisting on the use of a larger tire for a given weight than heretofore.

Edison has pointed out a strange paradox in the automobile. He says that the only thing which makes the automobile possible and practicable is the pneumatic tire, and at the same time the pneumatic tire is the weakest point in the automobile. The solid rubber tire, while successfully used on commercial vehicles at slow speeds, has not been, and cannot be, successfully used on touring cars or racing machines. The writer has made some experiments along this line, and has found that the jar and hammer incident to driving a touring car over rough roads are so great that the machinery of the motor car will not stand the shocks and strains.

The fuel problem is becoming a serious one for the automobilist. Within the past ten years, the demand for gasoline has increased enormously, and the price has almost doubled, while the supply has increased but little. The oil fields of Texas and California do not furnish the kind of oil from which gasoline can be manufactured.

It is a fact not well known that the farmers of America use more gasoline than the automobilist. Eight hundred thousand gasoline stoves are in use throughout the Western portion of the United States where fuel is high in price. The supply of gasoline within five years or less will be entirely inadequate to the demand, and the price will necessarily advance to prohibitive figures. The most practical solution of the matter is to secure the passage of an act by Congress taking off the tax on denaturalized alcohol used for commercial purposes. This is now being agitated. The present tax is $2.08 per gallon.

Vegetable alcohol may be made from corn, beets, potatoes,—in fact, from any of the starchy products. It can be made and sold at a price which is no greater than that now paid for gasoline. Last year over two hundred million gallons of vegetable alcohol were used in Germany.

It is very successfully used for general fuel purposes and in the internal combustion engine. By removing the government tax on denaturalized alcohol, the fuel problem for motorists would not only be solved, but a new industry would be encouraged in America, and one which would be not only profitable to the manufacturer, but which would furnish the farmer a substantial market for the surplus products of his land. Some of these are now entirely wasted.

For example, two years ago the potato crop in Maine was so abundant that potatoes sold at 25 cents a barrel, and many thousand bushels were left to rot in the ground. These potatoes could have been made into vegetable alcohol profitably had it not been for the handicap of the government tax. A bushel of corn will yield two and a half gallons of alcohol. The surplus corn crop this year would yield seven hundred million gallons. In years of surplus of farm products, alcohol could be manufactured and stored, and the price thus kept at a stable figure.

An important field which must not be overlooked is that of the electric car. Most of the electric trucks and commercial vehicles seen about American cities at the present time are driven by electric motors. As a pleasure car for city and suburban use, combining cleanliness, noiselessness, reliability, and ease of operation, the electric automobile cannot be equalled by any other type. It may be driven by the fair sex with perfect ease, comfort, and safety. As an illustration, Mrs. W. E. Scarritt, of East Orange, N. J., has driven her own electric car over 16,000 miles without the slightest accident of any kind.

The main problem involved in the use of the electric car is the battery, which has to be nursed and petted, and humoured and exercized much as a spoiled child. Some type of the lead battery is most used. If it is charged too rapidly, the plates buckle and are ruined. If it is overcharged, that is, charged for too long a period, the same mishap follows. The car cannot be driven until the batteries are exhausted, because this is injurious. The car must not be permitted to stand without use for over 48 hours, as a sulphate will form on the plates, which will cut down the mileage of the car very seriously. It is just as necessary and quite as important to charge and discharge a battery, in order to keep it in good trim, as it is to exercise a horse.

These requirements are serious drawbacks to the use of the electric vehicle. But it is gratifying to learn that Edison has constructed a battery to which none of these objections apply. It may be undercharged or overcharged, slowly or rapidly, or it may be exhausted to the lowest ampere; it may be left standing for weeks or months, and no harm will come to it. The world will yet acknowledge its deep indebtedness to Edison for his storage battery as it has already done for the incandescent electric lamp.

The standard car of the future, whether for pleasure or business, will be of the gasoline type. It will be simple, and will be constructed of the highest grade of material known to the art. Reliability rather than speed will be the great desideratum. It will become standardized, and when standardized it can be made in large quantities at a low cost. I believe the automobile, so far as cost is concerned, will follow the way of the bicycle. In the near future I expect to see a very fair runabout sold for $300, and the same grade of touring car for $500.

In conclusion, it may be well to consider some problems which are to be solved by this new factor in civilization. First, it will tend to prevent traffic congestion in city streets. A single example:—What would it be worth if Broadway, New York's main thoroughfare, could be doubled in width from its lower end for a distance of, say, 9 miles?

Broadway is no wider than it was

a hundred years ago, and yet the traffic upon this highway is a hundredfold greater than it was then. A horse-driven truck starting from one end will make the 9-mile trip in two hours, carrying a load of a ton and a half. Substitute the motor truck, and what follows? The space occupied by the horse, which is about equal to that of the truck, is saved. Further, the motor car will carry three tons, and can make the trip in just half the time of the horse-drawn vehicle. Thus, it is seen that the use of the motor vehicle would not only double, but more than treble, in effect, the width of the street.

Second, the automobile will tend to solve the tenement house problem. Automobiles ultimately will be built and sold at so low a cost that the average city workman will be able to own one, as he now owns his bicycle. Thus, he will be enabled to own his acre, away in the country, and bring up his children in the sunshine and fresh air among far more pleasant and healthful surroundings than are possible in the crowded tenement house districts of large cities.

Third, the use of the automobile in country districts will tend to keep the young people from flocking to the cities. The automobile will make life on the farm more pleasant. Young people will be able to go about visiting neighbours and friends even in adjoining counties, and in the future we shall probably hear less of "abandoned farms."

Fourth, the automobile will become indispensable to the physician, and I have no doubt that countless human lives will be saved, because, through the use of the motor car, the physician will be enabled to reach patients in a critical condition more quickly than by any other available means. The automobile will also become invaluable to firemen, to officers of the law, and to others in situations where great speed of transit is a desideratum.

It would take a man with a prophetic eye to look into the future and discover all the problems which the modern motor car is to solve. We may be sure that it is not a fad nor a plaything, but that it has "arrived," that it will remain an important factor in civilization, and that it will be for countless generations to come the faithful ally and servant of mankind.

VOLTAGE AND COSTS OF ELECTRIC TRANSMISSION LINES

By Alton D. Adams

DISTANCE, rather than voltage, is the prime factor in the cost of transmission lines. Contemplation of that beautiful law of electric circuits, that the percentage of power lost, and also the weight of conductors remain constant if the applied voltage varies with the length of line, sometimes obscures the fact just stated, but a cold engineering estimate brings it again to view. If electric conductors floated in mid air and did not require any particular mechanical strength, the question of line voltage would, indeed, be of first importance; but while poles, pins and insulators are necessary, the question of line cost is not merely one of voltage, as is sometimes said.

Costs of transmission lines may be divided into those for conductors and those for supports. Within rather narrow limits the cost of conductors may be held constant by varying the voltage directly with their length. Over much wider limits the cost of

supports for the conductors varies nearly as their length, whatever the voltage employed. For rather short transmissions, say under twenty or thirty miles, where the total cost of the line is only a moderate fraction of the investment in the entire plant, there is not so much reason to lay stress on the distinction between the cost of conductors, and that of supports; but on very long lines, like the recently much-talked-of 700-mile transmission to connect Victoria Falls on the Zambesi River, in South Africa, with the mines of the Rand, the cost of supports alone becomes one of the main items, if not the greatest item, of the investment.

The very fact that the weight and cost of conductors for a given percentage of loss remain constant if the voltage of transmission increases directly with their length, while the cost of supports increases at nearly the same rate as does the length of the line, implies at least a constant approach of the cost of supports to that of the conductors. Were it not for the circumstance that, in practice, the cost of conductors cannot be held constant over any great range of length, the cost of supports would rise above that of line wires long before the limits of existing transmissions were reached.

If the voltage of a transmission is increased with the length, so that the weight of conductors may remain constant for the same percentage of loss, then the cross-section of each conductor must grow smaller, being only one-half as great for 200 as for 100 miles, if designed for the same amount of power. The consequent reduction of mechanical strength in the conductor thus puts a limit to the practicable voltage for many lines. On a long line of 50 miles or more, it would, in most cases, be undesirable to use a copper conductor smaller than No. 1 B. & S. gauge, though on some short transmissions of from 10 to 25 miles, wires as small as No. 4 B. &. S. gauge may be found. But reduction in the size of conductors for a transmission line, due to an increase of voltage, would in many cases work no decrease in the cost of supports, in spite of the smaller weight to be carried. With the higher voltage would come the necessity for a greater distance between wires, somewhat longer poles and cross-arms, and larger pins and insulators, so that these items might fully offset the advantage of less weight in conductors.

It is now the most common and probably the best practice on long transmissions at high voltages to mount each three-phase circuit on a separate pole line, where wooden poles are used. For a 50,000-volt, three-phase circuit the conductors should be mounted on insulators at least 6 feet apart, and the length of each pole above ground should be not less than 35 feet. The standard distance between the poles may properly be 100 feet, and a fair allowance for shorter spacing on curves and corners brings their number per mile up to about sixty.

Let these poles be of good quality cedar, fit each one with a heavy cross-arm, and three steel pins carrying 50,000-volt insulators, erect them on clear solid ground, add all necessary guys and braces, string the line conductors, and a moderate cost will be $10 per pole, or $600 per mile, counting nothing for the line conductors or the right of way.

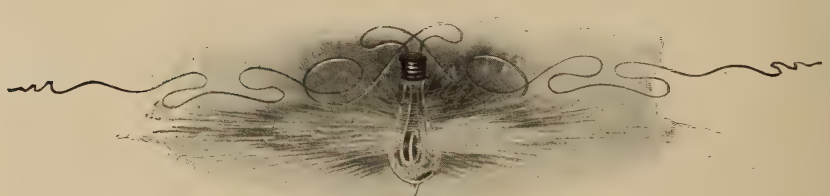
If three No. 1 B. & S. gauge wires are strung for a three-phase circuit on these poles, and about 5 per cent. is allowed for sag and corners, the total weight of the conductors will be 4200 pounds per mile, costing $630, on the basis of 15 cents per pound. No matter how far this line may run, or how high its voltage may be raised to compensate for long distances, the cost of the conductors named will continue to be about equal to that of their supports, under the stated conditions.

An actual case similar to the one suggested is that of the 65-mile line

between Cañon Ferry and Butte, in Montana, where each of two three-phase circuits is carried on a separate line of poles. These circuits operate at about 50,000 volts, and each consists of three No. 0 B. & S. gauge copper wires, having a combined weight of about 5100 pounds per mile, and a consequent cost of $765 for that length, at 15 cents per pound. If the pole-line cost in this case corresponds to the estimate previously made, then the cost of the conductors is greater than that of the supports by only 26 per cent.

Suppose that the length of this last named line were increased to 200 miles, and that the operating voltage were so raised that the same percentage of loss would be maintained without increasing the size of the conductors. Evidently the higher voltage would require greater distance between the conductors, longer poles and cross-arms, and more expensive insulators, all of which lead to a higher percentage of the total investment in supports.

Take another case,—the 60,000-volt transmission over a line 100 miles long to Guanajuato, Mexico. A single circuit of three No. 1 B. & S. gauge copper cables on steel towers makes up this line. Each standard tower is 40 feet high and weighs 1500 pounds, and there are twelve of these towers per mile on straight work. In the United States these towers could probably be erected and the three conductors strung at a cost of 6 cents per pound,—$90 per tower, or $1080 per mile for everything complete, except the price of the conductors and of the right of way. In Mexico, the cost may have been as high as 9 cents per pound, or $1620 per mile, for the same materials and labour. At the cost of $1080 per mile, in the United States, the steel towers of the Guanajuato line represent an investment that is greater by 70 per cent. than the cost of the No. 1 copper conductors which they support, at 15 cents per pound. If this line were increased in length to 300 or 400 miles, and the voltage raised so that conductors of the same size could be used, the relative cost of the supports would be greater rather than less. These facts it is well to bear in mind in considering transmission projects. Frequently they are overlooked.



TENDENCIES IN POWER PLANT DESIGN

By George L. Clark

ENGINEERING progress is nowhere better illustrated than in the modern power plant, which is in every sense a complex industrial organism in process of evolution. The power plant of to-day bears little resemblance to the installations which were regarded as triumphs of engineering in the early nineties, and the contrast between the plant of 1906 and the power house of even five years ago is full of significance to the designing expert. Small wonder it is that the design of power plants has become an engineering specialty requiring almost the entire attention of those who practise in this particular field.

In point of size, the modern power plant has attained a development which eclipses all previous work. The generating units of to-day are individually larger than the great majority of entire central stations were ten years ago, and the end is not yet. Already the signing of a contract for a 7500-H. P. generating unit, costing perhaps $150,000, attracts little attention outside the immediate professional and manufacturing circles concerned. The 10,000-KW. unit is almost commonplace. Possibly this capacity might, for several years, represent the limit of operating convenience, did not the electrification of great steam railway systems loom up so close at hand.

No man can say what will be the maximum rated output of the power house units, which, a few years hence, will be operating the denser traffic of the railways in the vicinity of the larger cities, and probably supplying power to both trunk and branch line routes in the more thickly settled parts. Given a 2250-H. P. electric locomotive, like the New York Central Railroad Company's type, taking 3000 H. P. on overloads and capable of being operated with others of the same size in trains, on the multiple-unit system of control, it is evident that the power house units to supply a single division must be mammoth machines if the operating simplicity of the generating plant is to be retained. The same kind of reasoning applies equally well to the alternating-current locomotive's demands upon the generating system.

Along with this vast increase in size, the power plant of to-day represents the adoption of labour-saving methods to an extent little realized a few years ago. The small motor has become an important accessory in the operation of heavy valves for both regular and emergency service, in the driving of coal crushers, conveyors, economizer scrapers, air compressor for cleaning, turning over engines for valve setting, cleaning or commutator truing, operating hoists, pumps, and remote control switches. A small machine shop is almost always a part of the equipment of a modern large plant, and the group-driving of the machinery by one or two motors is a matter of course.

All these improvements are making the power plant attendant's daily work much easier, as far as manual labour is concerned; and it is well that this is so when one considers the responsibility which attends the care of the present expensive equipment. The power house has been slow to appreciate the importance of welfare work, but the 12-hour day is fast disappearing; the larger stations often operate, in fact, with 8-hour shifts, and it is gratifying to note the general provision of shower baths and other facilities for physical com-

fort. There is also a tendency to adjust wages with more regard to responsibility, and the chief engineers of some of the larger power plants are as well paid as many distinctly professional men.

The treatment of the power plant cycle as a manufacturing process is followed by all progressive designers. In the efforts which are constantly being made to turn out a kilowatt-hour at the bus-bars at minimum cost, lie the possibilities of future economy. Existing plants offer an attractive field for this sort of work, and the older the installation, the better is the prospect of accomplishing telling results. There is little doubt that the efficiency of electrical generators has been pushed pretty close to the limit of human possibility, and that the power plants of the future will excel those of to-day in the generation of mechanical, rather than electric, power. The losses which occur between the coal pile and the generator are so large, even in thoroughly modern steam plants, that they deserve the constant study of every power-plant designer and operator.

H. G. Stott's recent paper on "Power Plant Economies," before the American Institute of Electrical Engineers, shows the discouraging inefficiency which hangs like an incubus upon the steam end of even a representative modern installation. In a case analyzed by him only 1452 B. T. U., out of one pound of coal starting with 14,150 B. T. U., were delivered at the bus-bars. Of these tremendous losses, 3212 B. T. U. were thrown away in the stack; boiler radiation, and leakage accounted for 1131; and condenser rejections, for 8524 B. T. U. If the output of such a plant were supplied to ordinary $3\frac{1}{2}$-watt, 16-candle-power lamps, located even a moderate distance from the station, it is safe to say that not over 50 or 60 B. T. U. of the original 14,150 would appear in the form of light, at the consumer's premises.

Operating economy is, therefore, the chief end of power-station development. The evolution of prime movers is all directed toward the production of power at greater efficiency. Upon the completion of a new plant it is often difficult to see where any radical improvement could be made in the arrangement of the equipment, but the apparatus itself is constantly being improved by the manufacturers.

The battle between the reciprocating engine, the steam turbine, and the gas engine shows little sign of abating, but the field of each machine is becoming better defined. It is impossible to predict the outcome of this competition of motive power as long as the cost of coal does not greatly advance; but in the distant future it is highly probable that the internal combustion engine, using alcohol as a fuel, will attain a development of huge proportions. Power-station design is largely determined by the type of prime mover employed, and the available supply of fuel has a vital bearing upon the whole subject.

The broad tendencies of power-station design, then, are in the direction of better operating economy, labour-saving improvements, larger units, and better working conditions for the attendants on duty.

In addition every attention is now given to reliable service, and incidentally the fire risk is receiving a larger consideration. The external architecture of power station buildings in several notable instances, too, bears evidence of a pleasing appreciation, on the part of designers, of the possibility of combining utility with a reasonable measure of ornamentation. Doubtless this idea is carried to extremes in some places, but in general and for the present there is little danger of æsthetics receiving too much attention.

Current Topics

The Zambesi River power scheme in South Africa, of transmitting the energy of Victoria Falls electrically over about 700 miles of transmission line—and possibly even by the use of direct current after M. Thury's system,—has latterly been an absorbing topic of engineering discussion. Quite aside from alternating-current and direct-current considerations, however, the commercial aspect of the project has been vigorously taken up, the possibility of commercial success having been denied. Professor Wm. E. Ayrton, for example, severely criticized the scheme recently in the London "Times," and condemned the comparisons made between the Victoria and the Niagara projects. The Niagara plant, as he remarked, delivers electric energy over a distance of only 30 miles, while the Zambesi plant, with the South African Rand as the only available power market, nearly 750 miles away, would have a vastly more serious transmission problem to consider. At present the Rand consumes about 150,000 H. P. at a cost of something like $100 per year per horse-power. Niagara sends 24,000 H. P. to Buffalo, 30 miles away, and sells it at about $125 per horse-power-year. There is a plentiful supply of coal in the neighbourhood of Johannesburg, and estimates have been obtained and accurate analyses made of about twenty different kinds of coal, with the result that at a price of $2.60 to $3 a ton, excellent coal can be delivered on the Rand itself. How is it possible, therefore, asks Professor Ayrton, to "transmit electric energy 745 miles and sell it more cheaply than it can be obtained from coal on the spot?" He also points out the dangers from native interference with the line, and summarizes his objections to the scheme in the sentence that "such lengthy transmissions, more than three times as long as have ever yet been made, because more than three times as long as even the enterprising Americans have ever yet considered commercially possible, could certainly never succeed in such an unsettled country as South Africa."

As is generally known, oiling dusty roads and railway roadbeds has been practiced for several years past in different parts of the United States with varying degrees of success. In

some places the results have been gratifying; in others they have not. The difference appears to lie largely, if not entirely, in the quality of the oils used, the successful kind being a heavy crude petroleum with an asphaltum base, used in the Western sections of the country, principally in California. The asphaltum unites with the road material into a hard waterproof surface cake, free from the oily dust nuisance to which oiled roads elsewhere have given rise. Altogether the California oil is said to be quite different in its effects from those of the lighter and thinner Eastern oils.

ACCORDING to a tabulated statement of the breakdown of electrical machinery, given in the recent annual report of Michael Longridge, engineer-in-chief to the British Engine, Boiler & Electrical Insurance Company, of Manchester, dirt and neglect were responsible for 13 per cent. of the failures of dynamos, and 19 per cent. of those of motors. No less than 20 per cent. of the failure of dynamos, and 16 per cent. of those of motors, were due to bad workmanship or design. "It is well to bear in mind," says "The Engineer," of London, in commenting upon these figures, "that the dynamo or the motor would not be paid for unless it stood the preliminary test. It follows that there was some congenial condition which enabled it to work, and that the final breakdown was due to deterioration, which might or might not have been stopped, minimized, or made harmless by proper care. We have here a standard of merit. Two dynamos or motors may work equally well at first, but one can only be kept going subsequently by incessant care and watchfulness, while the other will in large measure look after itself. Electrical machinery easily goes wrong, and there is no mechanism in the world of which success depends so much on little things. Thus we hear of a 38-H. P. motor which broke down because of short circuits established between the spokes of the commutator by iron ore dust. But the casing of the motor was air-tight, and the only way in which the powdered ore could have got on the commutator was from the clothes of the man who adjusted the brushes. Here is another case:—Completely enclosed 4-brake H. P. Lundell motor, taking current at 250 volts. The motor broke down. When opened, the lower part of the field coil was found to be saturated with oil and partly burnt out. The oil had run down from the bearings and accumulated in the bottom of the casing, which was, as usual, unprovided with a drain. It seems that not a few electrical engineers, while devoting much attention to the attainment of a high efficiency, forget to introduce those features into their designs which are really essential to their satisfactory performance in daily life."

THAT the size of warships is rapidly increasing is common knowledge, but the extent of the average increase is by no means so well known. The number of warships of 12,000 tons displacement or over built and building for the several naval powers on July 1, 1899, was 77, of which 46, or 60 per cent., belonged to the British navy. In 1900 the number was 94 (British, 48, or 51 per cent.); in 1902 there were 101 (British, 53, or 48 per cent.); in 1903, 139 (British, 64, or 46 per cent.); in 1904, 155 (British, 70, or 45 per cent.); in 1905, 153 (British, still 70, or 47 per cent.). It will be noted that the falling off this year was due to the loss of a number of Russian ships. The number owned by the United States increased from nine in 1899 to 14 in 1902, 23 in 1903, 26 in 1904, and 28 in 1905. In the last year France is credited with 15; Italy with 11; Germany and Japan with 10 each, and Russia with

9. In this connection it might be remarked that the average displacement of all warships, excluding torpedo craft, has increased successively from 3883 tons in 1899 to 4131 in 1900, 4416 in 1902, 4725 in 1903, 5010 in 1904, and 5739 in 1905. This shows an increase of 48 per cent. in six years, which is accounted for partly by an increased size of warships built, and partly by the "scrapping" of old-style ships, usually of small size. By this latter process Great Britain has brought her average displacement in the last year from 6293 tons to 9073 tons.

The average speed, too, of warships is rapidly increasing. Excluding torpedo craft, the warships built and building for the several powers in July 1, 1899, had a mean speed of 16.92 knots. This figure has become successively 17.24 in 1900, 17.49 in 1901, 17.89 in 1902, 18.17 in 1903, 18.39 in 1904, and 18.71 in 1905. This increase of nearly 2 knots is due largely to the construction of large numbers of large armoured cruisers, most of which are capable of steaming 22 knots or over, while the building of smaller and slow ships has heavily decreased. The mean speeds of the warships of the eight greatest naval powers in 1905 were:—Great Britain, 19.82; Japan, 19.41; Italy, 18.79; Austria, 18.65; United States, 18.64; France, 18.56; Germany, 18.18, and Russia, 17.29 knots. The fastest navy is that possessed by Chili, which, with only 11 ships, largely very swift cruisers, has a mean speed of 20.71 knots.

The conversion of waste products into profit is receiving more and more attention from iron and steel producers. While great strides have been made in the past, says "The Iron Age," large possibilities still appear. The utilization of waste products from blast furnace operations is only beginning to receive attention, and while the losses in finishing mills are not nearly so great as in the production of iron, they are considerable, and efforts at reclamation have resulted in profits of no mean proportions. Sulphate of iron as a water purifying agent with an admixture of a small percentage of copper sulphate is of comparatively recent use in mechanical filtration, and its merit as a coagulant, together with its low cost, has led to its employment in urban plants in all sections of the country as a substitute for aluminium sulphate. A new outlet has thus been developed for a waste product whose uses have heretofore been circumscribed, and the disposition of which at all large finishing mills where steel is pickled to remove the scale, before being drawn or rolled into a more highly finished product, has been a problem.

More attention is also being paid to the use of blast furnace flue dust, despite the many unsuccessful attempts at briquetting. Recent developments indicate that the latter has been given up as impracticable, and attention is now directed toward the agglomeration of the dust in rotary kilns. Nodules have recently been made containing 66 per cent. of iron, and it has been shown that their physical structure is such as to prevent disintegration in the stack before the zone of fusion is reached. Two of the largest producers of steel have already contracted for plants of the rotary kiln type. The outcome of these experiments is expected to be not only the agglomeration of flue dust, but also of the fine Mesaba range ores in the United States, which have been a constant source of annoyance and loss in the practice of most blast furnace companies.

Darwin's theory of the evolution of man from a lower species through the survival of the fittest, also holds

true in principle for the evolution of different types of machines. Thus "The Engineer," of London, says, that when the safety bicycle was first introduced there were large numbers of different shapes and patterns. Practically speaking, none of these shapes was exactly the same as the form of the present-day machine. Now-a-days nearly all safety bicycles are the same in general form, and differ only in minor details. The main shape of the frame, and the arrangement of the wheels and forks, differ but little over a wide range of bicycles by hundreds of makers. Very nearly the same thing can be said of locomotives, though the argument is not quite so strong in this case, for it does not hold good in all countries, as does that concerning the bicycle. Nevertheless, it may be laid down as a general principle that in time machines of all kinds gradually assume more or less the same form or type, no matter who makes them. This point is strikingly in evidence in the case of dynamos and motors, even the colour of the paint having become almost standardized. These remarks apply with equal force to other electrical apparatus,—the secondary battery, for example. The reason, of course, is that as time goes on it is found that some particular form gives the best results. It is another instance of the survival of the fittest, "the fittest" in this case meaning the handiest, most efficient, easiest and cheapest to make, and smallest in overall dimensions. The dynamo and the motor have nearly reached the limit of possible efficiency. Hence, in design at all events, it seems unlikely that we shall see any further very marked change in the future.

JOHN ALFRED BRASHEAR

A BIOGRAPHICAL SKETCH

By John L. Cowan

OBSERVATORY HILL, in the city of Allegheny, Pa., is the location of a modest workshop in which are made the optical parts of range finders and gun sights for the United States Government, together with telescopes, spectroheliographs, spectroscopes and astronomical cameras with which many of the great observatories of Europe and America are equipped. This workshop is known as the Brashear Astronomical & Physical Instrument Works, and is one of the leaders of its kind in the world. To the instruments made in this shop may be attributed some of the most remarkable discoveries of the last twenty-five years in astrophysical research.

John Alfred Brashear, the founder and present head of the works, was born in Brownsville, Pa., in November, 1840, and received his education in the common schools of that town. From his grandfather, Nathaniel Smith, he seemed to inherit a decided taste for mechanical pursuits, and after leaving school became an apprentice at the Snowden Engine Works in his native town. Finishing his apprenticeship in 1860, he accepted a position in Louisville, Ky., where he remained until the breaking out of the war in the South, and then came to Pittsburg, where he accepted a position as master mechanic in the rolling mill of Zug & Painter. He remained with this firm for seven years, accepted a similar position with McKnight, Duncan & Co., with whom he remained seven years, and then wound up his rolling-mill experience

by a seven years' engagement with Zug & Co.

His grandfather taught him the constellation at the early age of ten years, and from that time on he was deeply interested in astronomy. In latter years a friend loaned him a small telescope with which he made many observations, and he became so absorbed in the study of the heavenly bodies that he concluded to make a much larger telescope. A love affair devolved at this period of his life, which resulted in his marriage to Phoebe Stewart, who, from the very commencement of their married life, took a deep interest in her husband's hobby, and greatly assisted him in the construction of his first telescope. At this time he was working in the rolling mill, but when he reached home at night he found the workshop in fine order, steam raised in the boiler, and the little engine oiled and ready to start, all attended to by Mrs. Brashear's own hands.

The first glass, one of 5-inch diameter, required about three years for its completion, working in the night hours. After this telescope was finished it was found not to be as satisfactory as was anticipated, so a larger one of 12-inch diameter was commenced. This glass was practically completed in two years, but was broken by an unfortunate accident, greatly discouraging the two amateurs, but after a few days' rest, a new one of the same size was commenced, which was finished in a little over two months, owing to the valuable experience gained in working the former glasses.

With this telescope many observations were made on comets, nebulæ, the planets and the moon. A long series of observations were made by Mr. Brashear on the lunar crater Plato, for evidence of change. This work was undertaken in unison with a committee of astronomers, of which Birt, of the Royal Astronomical Society, of Great Britain, was the chairman.

Mr. Brashear originally undertook the making of telescopes and other astronomical instruments solely for use in his own observations, but it was not long before there was a demand for instruments, coming from others interested in astronomical pursuits, among them Professor Langley, of the Allegheny Observatory.

Many articles on comets, etc., were written by Brashear and published in the daily papers at this time, which, coming to the notice of William Thaw, greatly interested that gentleman in the astronomical work of Mr. Brashear, and after a visit to his place, proposed to build and equip a good workshop for the production of astronomical instruments. This unsolicited proposal was accepted by Mr. Brashear, and to the kind and interested help of this friend of science, he has always attributed much of his early success, and the friendship thus developed remained as a potent factor in his life work. Professor Langley also became a friend and advisor on the scientific side of Mr. Brashear's investigations; a friendship which has never been broken.

In 1881, James B. McDowell, very soon after his mariage to a daughter of Mr. and Mrs. Brashear, became deeply interested in the astronomical instrument work, and at the earnest solicitation of Mr. Brashear, associated himself in the development of the new plant, with which he has remained to the present, and to whose practical knowledge, gained through the years of experience during that time, much of the success attained is credited by Mr. Brashear.

The field of astrophysics was now ripe for the harvest. The investigator was in constant need of new implements of research, and as there was only one other place in America where such apparatus was made, it was not long until orders came for spectroscopes, spectroheliographs, telescopes, cameras for astronomical photography and other special apparatus required for investigation in the new field. Optical apparatus of the most delicate character was demanded,

surfaces with an accuracy of one millionth of an inch required; prisms of glass, quartz, rock salt, with surfaces of extreme precision were called for and successfully made.

In 1884, Professor Rowland, of the Johns Hopkins University, requested Mr. Brashear to make the speculum metal plates for his diffraction gratings. These also were made with limiting errors of one two hundred and fifty thousandth of an inch, and by the aid of these gratings, marvelous discoveries have been made in the domain of physical and astrophysical science during the past twenty years.

The optical parts of Professor Michelson's refractometer were next succesesfully completed, each requiring an accuracy of one-tenth of a light wave, or about one five hundred thousandth of an inch. With the refractometer, Professor Michelson determined the value of the standard meter of France in terms of light waves,—a work now classic in the annals of metrology.

During the Spanish-American war, many instruments of precision were made for the army and navy departments, inventions of an optical character having been developed which gave to these departments of the government many advantages in the firing of projectiles, not before known.

Just after the Spanish war, Mr. Brashear became interested in the building of a new astronomical observatory, as the old and honoured institution had become surrounded with dwellings so as to make it practically useless. Two hundred and forty thousand dollars were raised, and the new observatory is now nearing completion at the summit of a beautiful knoll in Riverview Park, Allegheny,—a charming spot, given to the Western University of Pennsylvania by the citizens of Allegheny.

At this writing, the great telescopes for the new observatory are being completed in the workshop of the John A. Brashear Company, Ltd., the firm now being composed of Mr. Brashear's son-in-law, James B. McDowell, and his grandson, John A. McDowell, J. B. McDowell having taken charge of all the optical work. Dr. Charles Hastings, the eminent mathematician of Yale University, is also an associate, calculating all the more difficult optical problems, some of which are of the most abstruse nature.

The scientific world knows of the high grade of work made by the Warner & Swasey Company, and none appreciates this more than the Brashear Company, the members of this firm having been warm personal friends of Mr. Warner and Mr, Swasey for nearly a quarter of a century.

The firm of John A. Brashear Company, Ltd., have been closely associated with the Warner & Swasey Company for twenty years, having made nearly all the optical equipment for their range finders, gun sights, field glasses, and for many of the splendid telescopes they have designed and constructed.

Mr. Brashear served as acting chancellor of the Western University of Pennsylvania from 1901 to 1904, but overwork forced him to resign January 1, 1904. He has been honoured with the degree of LL.D., by Washington and Jefferson College, and by Wooster University, and with the degree of S. C. D. by the Western University of Pennsylvania. He is an active member of the American Association of Science, American Astrophysical Society, American Philosophical Society, American Society of Mechanical Engineers, Pittsburg Academy of Science and Art, past-president and member of the Western Pennsylvania Engineers' Society, member of the Royal Astronomical Society of Great Britain, British Astronomical Association, Societe Astronomique de France, Societe Astronomique de Belgique, and honorary fellow of the Royal Astronomical Society of Canada.

HENRY GORDON STOTT

SUPERINTENDENT OF MOTIVE POWER OF THE INTERBOROUGH RAPID TRANSIT COMPANY, NEW YORK

SEE PAGE 527

CASSIER'S MAGAZINE

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ENGINEERING IN THE LOGGING INDUSTRY

IN THE AMERICAN PACIFIC NORTHWEST

By Henry Hale

A TIMBER GIANT

IN the logging industry as carried on in the forests of the American Northwest, especially in the States of Oregon and Washington, the system employed in recent years has been interesting from the standpoint of the engineer, owing to the evolution which may be said to have taken place in the methods of tree felling, preparing the material for the saw-mill, and its transportation to the plant where it is converted into lumber in the various commercial forms.

In the woodlands of such States as Michigan and Wisconsin, among the pineries of the Carolinas, Mississippi and Texas, the task of reducing the tree into timber is no small undertaking, remembering that the yellow and white pine species alone reach a height of 100 and 150 feet from the ground and a diameter varying from two to four feet at the butt. In contrast with the fir which so largely composes the growth of the Pacific Northwest, however, they seem small in proportions. It may not be generally known that many specimens of fir found on the shores of Puget Sound equal in height the famous giant sequoia or "big tree" of California, for firs have been cut down which were over 325 feet in length from the topmost branch to the edge of the cut, not including eight or ten feet of the trunk left standing above the roots. Bearing in mind that the fir will range from five to fifteen feet in diameter and that the bulk

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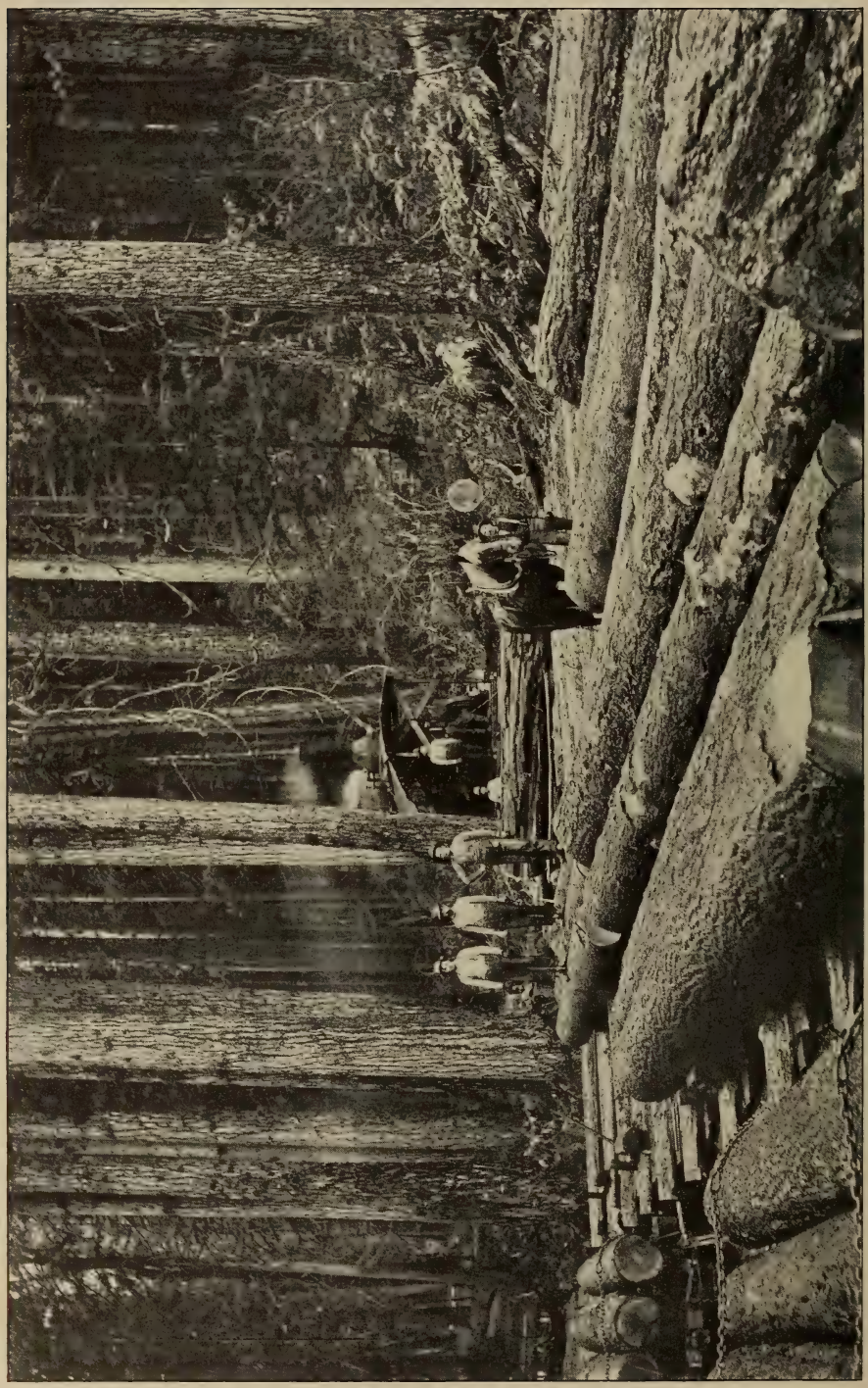


A TIMBER SKIDWAY

of the forests is composed of trees standing nearly 250 feet from base to top, it may be realized that in felling them skill as well as labour is required. Opportunity has been afforded to apply principles of engineering in the method of cutting and handling, and to design labour-saving machinery which has effected an interesting transformation in the old-time methods.

In a description of the industry it is essential to note briefly its great proportions in the Pacific Northwest. Fifty thousand square miles of Oregon and 45,000 square miles of Washington, or over half the area of these States, are yet covered with forests of the first growth of fir, cedar, spruce and other species, the fir and cedar representing the greatest percentage. The 450 saw mills in the State of Washington turn out over two thousand million feet yearly, while the output of the 500 Oregon mills is 1500 million feet. The number of mills is small contrasted with similar plants in Michigan and Wisconsin, for example, but they make up in capacity to a certain extent what they lack in numbers.

Individual mills on Puget Sound, on the Columbia River and other inlets connecting with the Pacific Ocean are remarkable for their size. At Port Blakely, on one of the islands of Puget Sound, is the largest saw mill in capacity under one roof in the world. In a year it converts 100 million feet of logs into square timber, planking, boards and smaller sizes, much of the output being loaded on shipboard at the mill for South and Central America, Mexico, and Europe. The largest group of sawing plants owned by one company is situated on Tacoma harbour, in Washington, and is owned by the St. Paul & Tacoma Lumber Company, while the largest shingle mill in the world is in the town of Ballard, a suburb of Seattle, producing solely cedar shingles.

To supply the requirements of a saw mill industry of such dimensions it is evident that an enormous quantity of standing timber must be cut annually. Consequently logging, as conducted in the Pacific Northwest, is of very large proportions, giving employment in the States named to fully 15,000 men. It may be needless to say that it is entirely distinct from the milling industry proper, although the two are frequently confounded and the work of the logger is placed in the same category with that of the millman. But this is an error, for the service of the logman ceases when the logs are made up into the raft to be towed to the mill or are loaded upon railway cars and started for the same destination.

To the uninitiated it may not seem a difficult undertaking to saw or chop down a tree. As a matter of fact, the making of the incision is not difficult. But some of the problems to be solved are,—where and how will the tree fall, how will it be reduced to a form to enable it to be transported, and how can it be transported? These problems are not so simple of solution when it is known that a 24-foot log sawed from the lower part of one of the larger firs will weigh from thirty to forty tons, —over a ton to every linear foot,— such is the density of the wood and the great diameter. Therefore, the part of a single tree available for logs may exceed 150 tons in weight. In solving these problems, and considering the size and weight of the material secured for the mill saw, a very small amount of manual labour is employed.

The organization of a logging camp in the Pacific Northwest is worthy of description. It is divided into the felling gang, the sawyers, the skidders, the swampers, the yarders, the loaders, and if the logs are transported by water, the boomers or raft makers. This does not include the crews of the stationary and traction engines or the rail locomotives and the camp cooks. The camp is under the general supervision of a

A STEAM-DRIVEN CROSS-CUT SAW, POWER BEING TAKEN FROM A TRACTION ENGINE

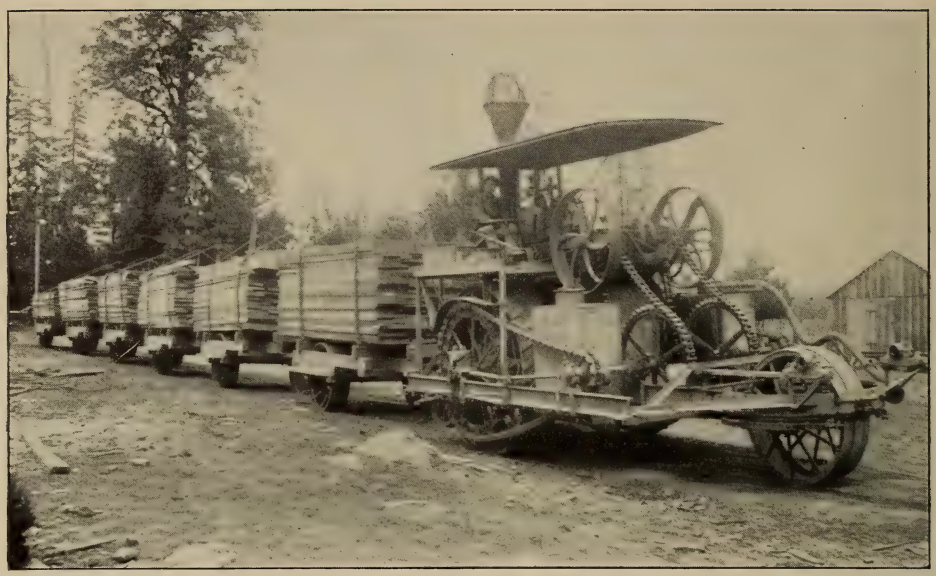
A GASOLINE ENGINE HERE SUPPLIES POWER FOR THE SAME PURPOSE

foreman, who might be called a timber engineer, since he should be sufficiently familiar with the work of every gang to know whether the falling tree is liable to have some "side winders" or whether the wire cable holding the logs in the raft has been thoroughly spliced. He sometimes performs the duties of the "timber cruiser," the expert who goes through a tract of fir or cedar, and, merely by eye measurement of the dimensions of the trees, can roughly estimate the number of feet, board measure, which can be cut from an acre.

A BETTER VIEW OF THE SAW DRIVING MECHANISM DESCRIBED ON PAGE 448

The preliminary operations in getting the timber out of the tract of woodland are the construction of the skidway or skid road and the preparation of the beds on which the trees are to fall. Since the weight of a 250-foot fir is such that if the impact of its fall is not gradually checked, the force with which it strikes the ground may split the trunk and possibly make it useless except for small sizes of lumber, the "swampers" prepare the bed, under the supervision of the foreman. If the tree to be felled stands upon a hillside or where the surface of the ground has an incline upward, advantage is taken of this to throw it towards the upward incline. The distance of the fall is thus lessened, and the logs can, of course, be pulled more readily down hill than upward. Patches of soft ground or a thick growth of underbrush also aid the loggers, as the force of the fall can be broken if the trunk descends upon the swampy ground or the undergrowth; but usually piles of boughs are placed along the "falling line," so that the trunk will first strike these, the piles acting as buffers.

When the foreman or undercutter has decided the direction in which the tree is to be cut down and the bed is prepared, the first incision is usually made with the axe, two men cutting in from opposite sides. When the incision has reached a point about one-third of the distance through the trunk, another is made from the opposite side with a crosscut saw driven by hand or other power. This incision extends about half way through the trunk or until the undercutter who is in charge of



HAULING LUMBER WITH A TRACTION ENGINE

the felling gang thinks it is deep enough. The next step is to guide the trunk in the right direction, which is done by driving wedges into the incisions. When this work is performed, it may be necessary for the axmen to cut a few more chips. Then the cracking of the wood which remains uncut in the "hinge," as it is termed, gives notice that the tree is beginning to fall, and the men hasten to a safe distance from it. If the wedges have been driven in the right places, the trunk strikes the bed prepared for it and is seldom injured.

The two principal elements of danger in cutting down one of the larger trees are the wind and a fall in the wrong direction. If the wind is blowing strongly, its pressure against the upper branches may cause the trunk to veer in its descent. If it is unobstructed, the men who may be on that side have time to get from under it; but often it crushes down smaller trees, and most of the accidents in the logging camps come from these "side winders," as they are called.

The next step is to trim the trunk and cut it into suitable lengths for the mill. By trimming is meant the removal of the branches and knots, if there are any. One side of the trunk is also stripped of the bark to lessen the friction in sliding along the skidway. Then the cross-cut saw again comes into play, severing it into the requisite lengths. Power is applied in a novel form in driving these saws. The engine is belted to a shaft carrying a small fly-wheel. At the end opposite the fly-wheel this shaft carries an eccentric gear, which pulls the saw back and forth. The illustrations on pages 446 and 447 show the arrangement. The cutting can be done obliquely or horizontally as well as vertically. The apparatus is now being applied to tree felling as well as simply cutting logs. Power is supplied by a steam traction engine or gasoline engine, the latter being mounted upon a truck which can be taken readily from place to place by horses. As the maximum power required is not over 10 horse-power, the apparatus is so light that it can be moved about in the timber tract with little trouble.

While the trunk is being cut into

ANOTHER VIEW OF A LUMBER TRAIN

sections and stripped of its branches, the swampers cut down the smaller trees and underbrush which may be in the portion of the forest over which the logs must be hauled to reach the skidway. In the timber lands of Washington and Oregon, this skidway is usually composed of trunks of trees ranging from a foot to two feet in diameter. These are stripped of their bark and laid transversely upon the surface, being held in place by wooden pins or spikes driven into the ground at the ends, and strips spiked upon the tops of the logs. If possible, the skidway is laid in a swampy section of the forest, to keep the surface wet and slippery. It may have several turns, but at each corner a heavy snatch-block or pulley is fastened to a tree or post at the side of the skidway to facilitate the movements of the logging cables. The skidway usually reaches from the terminus of the steam railway track, sometimes the boom at the water's edge, into the forest, being extended as the timber is cut off. It forms a roadway which is practically indispensable in the transportation of logs of large size.

In hauling the logs to the skidway the old-time method of using "strings" of oxen and horses, sometimes a combination string of both animals, is rapidly being superseded by the steam engine in some form. If the growth of large trees is very dense, a stationary engine is sometimes placed at the end of the skidway. Upon the truck supporting the engine is mounted a drum, to which is attached a sufficient length of wire cable to reach the timber within a radius of a half mile or more. As fast as the fallen trunks are cut into logs, the cable is hooked around one end of the log to be moved and the latter is "snaked" to the skidway by reeling up the wire cable on the drum, the swampers having first prepared the way. As the friction is very great where the log is 8 or 10 feet in diameter, considerable power is needed for this method of transportation, and the steel cable used ranges from three-quarters of an inch to an inch in diameter. Consequently the traction engine is being employed extensively where the woodland is sufficiently open to allow it to be utilized. The type of traction

A LOCOMOTIVE DERRICK FOR HANDLING LOGS

engine in service develops from 60 to 100 horse-power.

The log is generally placed upon wooden rollers. Then a cable is stretched from the "tractor" and looped around the end of the log, which is thus pulled along, rollers being inserted under the front end as fast as needed. An improvement upon this method is a low truck with broad wheels. The truck is provided with an inclined plane, up which the log is pulled by the tractor. After the log has been fastened in place, the tractor is coupled to the truck frame and hauls its burden in this way. Where the scene of operations is within a short distance of a steam railway, the tractor hauls the logs direct to the railway line. In connection with saw mill operations it is of much value, since it will haul a number of truck loads of lumber weighing 150 to 200 tons,—a load which could not be managed by fifty of the strongest horses over the rough surface of that region.

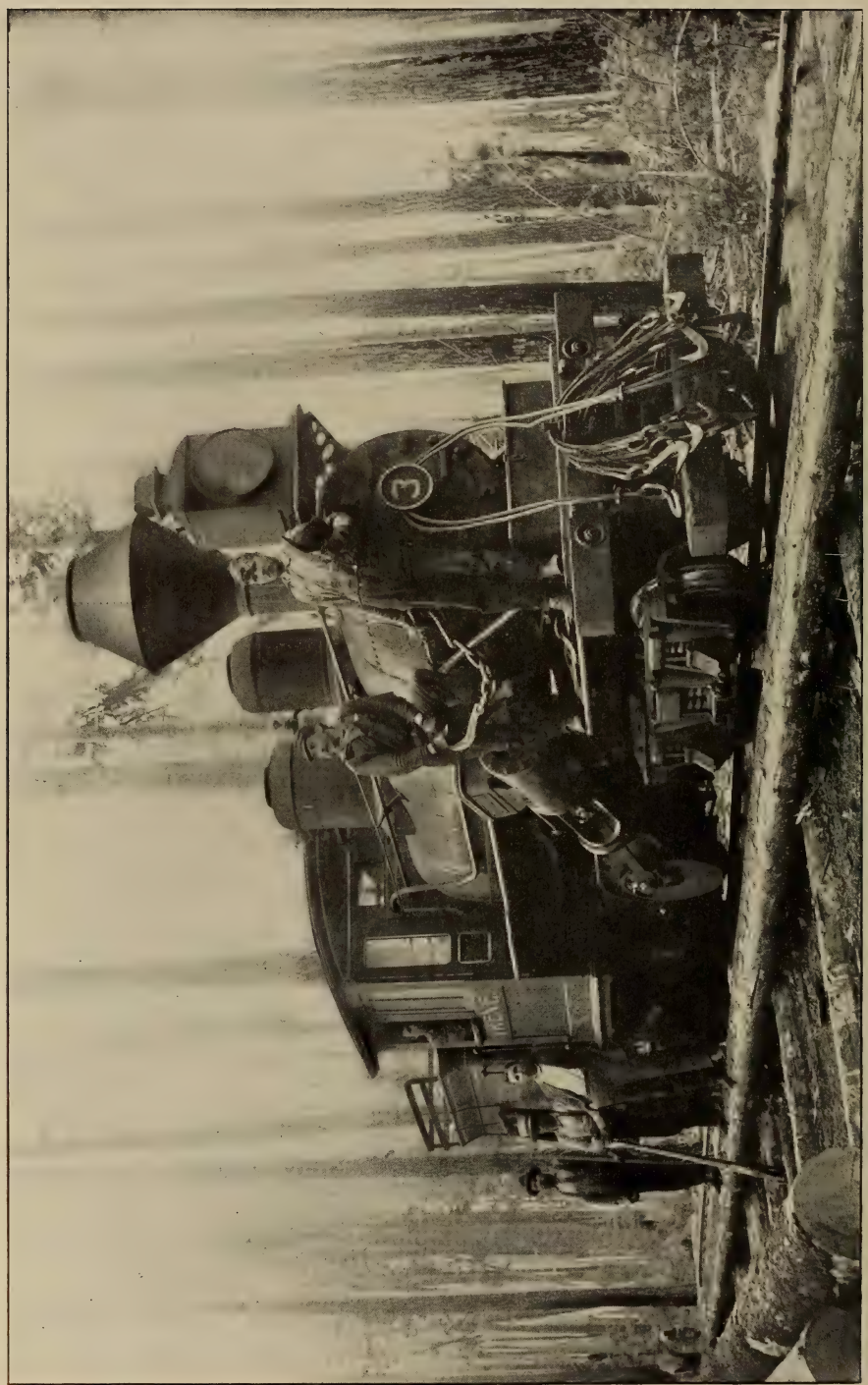
A locomotive boom derrick is find-

ing favour not only in Oregon and Washington, but in Michigan, Wisconsin, and Minnesota, for handling and transporting logs, since it will not only load cars, but, with the aid of the wire cable, will haul logs from a distance, and can be utilized either as a stationary engine or as a locomotive. It will load from 125,000 feet to 150,000 feet of timber in an ordinary working day, although a crew of only four men are usually required to operate it.

The most unique feature of the loader is that the trucks on which it is carried when acting as a locomotive are adjusted so that they can be raised several feet above the rails when it is desired to use the apparatus in a stationary position. This allows empty flat cars to be run beneath the loader, and facilitates, as well as economizes in, logging operations. The main framework of the loader is composed of steel I-beams, held together by channel bars and angles of suitable proportions. When the trucks are raised, the steel legs at each corner are lowered until the shoes to which they are attached rest upon the outer ends of the ties supporting the rails, thus leaving the latter entirely clear for the passage of cars. The legs are curved, and the length of the shoes affords a broad base which allows the derrick to handle very heavy weights.

When the loader is being utilized as a motor, the legs and their attachments are lifted above the track. Each axle carries a toothed wheel around which passes a heavy sprocket chain, leading upward to a sprocket wheel just below the engine platform. From there another sprocket chain connects with the main

THE DERRICK MAY BE RAISED FROM ITS TRUCKS, SUPPORTED ON LEGS, AND USED AS A STATIONARY MACHINE, AS DESCRIBED ON PAGE 453



A LOGGING LOCOMOTIVE

driving shaft. In this way sufficient power is made available to propel the loader along the track at a rate of six or seven miles an hour without cars. It will pull or push a train of loaded cars at a rate varying from three to four miles an hour on a level track.

The derrick consists of two legs, which are firmly anchored. The tackle used depends upon the work to be performed, consisting of either a single or double set of blocks for ordinary loading. When a car is to be loaded, the usual method is to grip the log at each end, the boom cable ending in two parts, each terminating in a hook. In this way pine logs 60 feet long can be lifted by the ends and placed in position, guided by only one man, as the end grip prevents them from slipping. So rapidly can timber be thus transferred that 75,000 feet have been actually put on cars in two hours.

In the skidding operation, the loader is run along the track to the place where it is desired to pile the logs or to load the trains. The trucks are raised and the machine is employed as a stationary engine. The logging cable is attached to a horse which pulls it to the log to be skidded. There it is hooked to one end and the log is pulled to the loading point merely by winding the cable upon the drum.

The skidding device is double-acting, two cables being usually employed, and while one is being hauled in with its load, the other is being run out for loading.

As already stated, the trucks, on which the loader is moved when the engine is utilized as a locomotive, can be raised so far above the track that an ordinary flat car can be run under the machine. By means of the boom and cable, cars can be hauled to either side of the loader, and trains "made up" without the assistance of a switching engine. When a car is to be loaded, it is placed directly in front of the loader and under the boom. When the piling has been completed the propelling trucks are lowered and the loader is run back until it is directly in front of the next car. Raising the trucks and lowering the legs, it is only necessary to extend the cable backward from the boom and underneath the loader, fasten it to an empty car and pull the latter forward beneath the boom when it can be loaded. After a sufficient number of cars have been loaded, the device is again converted into a locomotive, coupled to the nearest car, and the train is hauled to the mill or to the railway station, where the logging cars are attached to an ordinary locomotive and taken to their final destination.

Perhaps the most remarkable motor utilized for transporting logs has been in service in Michigan. For the reason that it is utilized during the winter season for handling timber through the woods, it is called a "snow locomotive." It is of about 200 horse-power, and can haul 100 tons of weight through snow-beds which range from two to three feet in depth, and across a country where there is not even a footpath. Under these conditions, the locomotive will attain a speed varying between three and four miles an hour, according to the condition of the surface over which it travels. On a hard and fairly smooth surface, such as packed snow or ice, it will develop a greater speed yet, hauling 150 tons.

This tractor differs radically in design from others which are utilized for hauling heavy weights. It was constructed after the plans of Mr. George T. Glover, of Chicago, its inventor, and possesses some peculiarly interesting features. The one illustrated on page 454 weighs twenty-five tons, but is attached to the runners in such a way that much of its weight can be shifted to bear directly upon what is known as the traction wheel. This portion of the outfit is a hollow cylinder of boiler iron, and is provided with a series of three-cornered teeth, which are set in

A SNOW LOCOMOTIVE

rows upon its face. Each is fastened to the wheel independently of the others, so that it can be quickly replaced if desired. The wheel moves upon a hinged frame, which permits automatic raising and lowering of the wheel or drum as it moves over the surface.

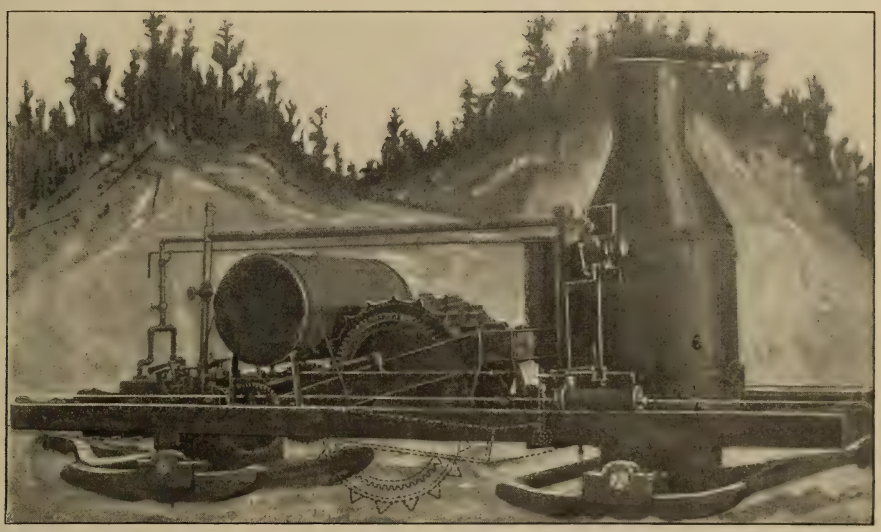
This traction drum is connected with a steam pipe through which the exhaust steam is discharged. This keeps the drum heated to a high temperature, and as it comes in contact with the snow it rapidly melts the latter, packing it down and making a firm surface for the runners of the engine and the trucks which follow it. In this way the motor literally constructs its own roadbed. The drum is made very heavy to withstand the hard usage it receives, the walls which support the teeth being an inch and a half thick. It is six feet in diameter, and weighs seven tons. When additional tractive force is desired, the weight of the engine is transferred to the drum by special apparatus. A powerful steam cylinder, called a "nigger," is so arranged that by merely pulling a throttle valve the engineer can operate it, with the result that the additional load is placed upon the drum almost instantly. The traction wheel is connected with the engine by gearing which permits of three degrees of speed. The slow gear is used in starting the train, in ascending grades, and in places where the route is more than usually difficult.

Some portions of the forest where the snow locomotive has been in service are low and swampy, being partly covered with water in the spring, while in mild weather in the winter season the snow may cover the soft spots to a depth of several feet, thus offering little resistance. It would be impossible for a team of horses to pass over some of these spots. Tests of the snow locomotive have been made by forcing it through this marsh land, and, with the aid of the traction wheel, the experiments have been successful. It has been used at the end of the winter season by substituting wheels for

runners. Even where the surface is largely composed of sand, it develops such traction that it can be forced through this material while hauling loads ranging from fifty to one hundred tons. In fact, its performances seem almost incredible, considering the topography of the country.

In Oregon and Washington the skidding of the log to the railway or boom is also performed by means of wire cable, but in "yarding" timber, as it is called, several logs are usually fastened end to end and pulled along the skidway by one engine, called by the loggers the "road donkey." It is of the stationary, double-cylinder type, and has an upright boiler generating from 100 to 150 horse-power, according to the service required. The engine and boiler are mounted on a massive framework of cast iron, and, including the cable cylinders, the installation weighs from forty to sixty tons. The engine turns two drums, thus furnishing the motive power for the skidway. The larger drum is used for the direct cable, which is made of steel wire and of sufficient length to extend to the end of the skidway. This is called the direct haul. The second drum is for the return haul cable. This is smaller in size, but double the length of the other. It passes directly from the donkey to the upper end of the skidway, where in the case of a door bell.

When the logs are ready to be taken to the railway or boom, they are fastened together, end to end, in "turns" of four or more, according to size. The direct cable is attached to the front of the "turn" and the return cable to the rear end. All of the forward pulling is performed with the larger cable by winding it on the drum, but if the "turn" becomes jammed or some other accident occurs, making it necessary to pull the legs backward, the donkey engineer reverses his engine, reeling in the small cable and paying out the other. The back haul is also needed in returning the direct cable for another load.



THE DRIVING MECHANISM OF A SNOW LOCOMOTIVE

Some of these novel transportation lines are operated by means of whistle signals, although the skidding crew may not hear them, owing to the distance from the engine. By the side of the skidway or through the woods is run a fine wire, ending

in a coiled spring so adjusted to the whistle of the donkey that it can be blown by pulling at the other end as in the case of a door bell.

When the engineer of the donkey engine hears two whistles, he knows the turn is ready to be hauled over the skidway, and pulls his lever accordingly. One whistle signal generally means to stop, while three whistles mean to back slowly. Some of the longer lines are operated by telephone.

If the logs are to be transported to the mill by rail, the usual method is to place them upon cars especially built for the purpose. A loading platform is constructed, level with the top of the car, the outer side of the platform being inclined gradually to the ground, so that the logs can be rolled up the incline by means of hand screw jacks, or by a cable which is fastened to the locomotive. The cars used on the railways reaching the fir forests have a capacity for carrying one to three logs to a load, depending upon the diameter of the tree. As most of the mills in the tide-water section of Washington and Oregon are on the water and supplied from a boom, the railway terminates on a trestle work extending over the boom, so that the logs can be dumped from the cars into the water by prying them over the edge. The logs are held on the cars by steel chains, the ends of the chains being bolted in such a manner that the blow of an axe or the prying bar will throw the bolt and leave the log free so that it can be readily rolled into the water.

The locomotives used on these logging railways in Washington and Oregon range in weight from ten to about fifty tons, the larger having a capacity for hauling a minimum load of 500 tons on a level. As yet, steam power is used almost entirely in this form of transportation, wood being burned for fuel. As the roadbeds are graded only when absolutely necessary, heavy grades and sharp curves require engines specially designed. Consequently the geared locomotive has been utilized on several lines. These locomotives will haul a train of twenty loaded cars up a 12 per cent. grade where ordinary locomotives having driving wheels of the smallest diameter would not be available.

The geared engine has also been used as a substitute for cable power, in yarding operations. A temporary track, laid with rails weighing 20 or 30 pounds to the yard, is put down on the surface, and the turns of logs are drawn over the ground between the rails, being fastened to the rear of the engine by hook and cable. As the cable for a skidway a mile in length costs $2000, and the yard donkey from $2000 to $4000, according to its dimensions and power, the use of the geared locomotive, and, in a level country, the ordinary logging locomotive with small driving wheels, is found more economical.

Another mode of yarding utilizes a stationary cable in place of rails. The cable is taken up by large grip wheels driven by an engine mounted on a truck. This grip wheel pulls the engine and car forward with the turn of logs in the rear. In the Pacific Northwest it is called the "Walking Dudley,"—the name of its inventor. Only a few of these motors are now in use.

Although most of the trunks of the larger trees in the Puget Sound region are sawed into 24-foot lengths, ship spars or bridge timber may be required, ranging as long as 125 feet. The longer pieces are usually rafted to the mill, owing to the danger and difficulty of handling them by rail. When a raft is made up, logs of uniform length are placed together, the width of the raft being from 60 to 100 feet and its length 600 to 1000 feet or more. As a raft of the greater size will hold over a thousand of the 24-foot fir logs of the average size cut in the Northwest, it may represent a million board feet of timber, and requires

no little skill in its construction. The logs are divided into sections, each section being held together independently of the others by "swifter lines" of wire rope which are stretched around them. The sections are placed end to end, and around the outside of the formation is placed a row of "boom sticks,"—logs of smaller diameter, but 60 or 75 feet long, so that they will overlap the joints between the sections. To the boom sticks are bolted not only the swifter lines, but heavy chains completely encircling the raft at intervals of fifty or a hundred feet.

If the boomers have done their work properly, this novel craft can be towed even in a heavy sea without going to pieces, despite its enormous weight and unwieldy proportions.

THE FIELD OF ELECTRIC DIRECT-CURRENT SERVICE

By H. L. Abbott

THE growing usefulness of the alternating current in many commercial applications of electricity has given rise to the feeling in some quarters that the days of direct-current service are numbered. There is not the slightest doubt that a great many of the duties once monopolized by direct current machinery can now be performed practically as well by alternating apparatus, and in cases where large amounts of power are to be transmitted over considerable distances the flexibility of alternating current in the matter of voltage changes gives it an almost insurmountable advantage over its older rival.

But in the enthusiasm which almost always accompanies the successful commercial development of new apparatus, it is easy to overlook the solid and tried advantages of established practice, and particularly is this true at the present time, when the alternating current motor is making such phenomenal conquests in the great field of railway transportation. Important as the changes are, it is well to realize what a strong grip the direct current still has upon many kinds of service, and to remember that an engineer may sometimes prescribe a continuous current system without being hopelessly out of date, or retain one in commission without falling out of the progressive class.

In considering the present field of the direct current, it is well to realize that the vast majority of railway motors are continuous-current machines, and that the great bulk of central station business in the congested districts of large cities is handled by direct-current equipment. Even in those cases where the distance of transmission has warranted the installation of high-tension, al-

ternating-current lines, feeding substations which, in turn, have become local centres of distribution, the direct supply of energy to the consumer is largely accomplished by continuous-current circuits. It is an open question whether there is any real economy in the use of alternating-current equipment in the business districts of large cities for general power and lighting work, although, of course, many special cases arise where the transformer or the induction motor is better adapted to the work in hand than any other equipment.

From the standpoint of the power station designer and operator, it is a great advantage to have to generate only one kind of current for sale, but in the commercial operation of a great distribution system a great many other considerations enter besides the first cost, operating efficiency, and convenience of the power plant.

The density of business which a given section of a community can supply really determines the character of the service best rendered. The field of electric railway work illustrates this. At the time when the single-phase motor came into prominence, a great deal was written and said about the immense advantage of its being able to operate upon both alternating and direct-current circuits, and predictions were not wanting that the older types of railway motors were bound for the scrap heap in double-quick time.

It was not long before the true field of the single-phase motor was seen to be, not urban service, but interurban service, especially where long distances and sparsely settled territory are found. The adoption of single-phase locomotives in America by the New York, New Haven & Hartford Railroad for its suburban service outside of New York and its trunk line service to New Haven was an epoch-working decision, and in the opinion of many engineers, the solution of the problem of steam railway electrification lies in that direction. At the same time, it is hard to believe that direct-current distribution is not as well suited to the handling of the densest suburban traffic as alternating current promises to be useful in handling train movements many miles away from the power station. There is very little prospect that the direct-current motor will soon be driven from the field of urban street railway work, including surface lines, subways, and overhead routes.

Perhaps the most obvious reason for the retention of direct-current service in the larger cities is the enormous investment which existing systems represent. Hundreds of thousands of horse-power in motors, and almost countless arc and incandescent lamps are owned by the electricity supply companies or their customers, to say nothing of the investment in generating machinery, mains and feeders, the latter being frequently placed underground at heavy expense. It is perhaps a peculiarly American characteristic to discard industrial equipment as soon as it is rendered obsolete by the invention and manufacture of improved machinery and appliances, but even in America in the matter of direct-current service it has yet to be proved that the alternating current possesses great enough advantages to replace the existing service in territory where direct current is being economically supplied.

In some of the smaller cities managers of electricity supply companies have reached the point where no direct current is sold outside their stations, but in such cases the original investment in generators and underground lines has generally not been high enough to make the change very expensive. From the standpoint of simplicity, there is much to be said in favour of this policy of co-ordinating the physical plant, but it is very doubtful if the low-tension area of distribution is any better off for the change, con-

sidering the increased cost of alternating-current motors over direct-current machines. In large systems the company must stand the expense of changing over from direct to alternating-current motors, for its customers will not bear the burden of substitution.

In an admirable paper upon direct-current distribution in American cities, read before the last International Electrical Congress by Mr. Alex. Dow, it was pointed out that there is small prospect that even the polyphase motor will ever be built in American shops at a cost materially less than the direct-current motor. The cost of a direct-current rheostat is less than the cost of a compensator or starting resistance, and the complication of the stated winding offsets the cost of building the commutator and brushes of the direct-current motor.

An important point in favour of direct-current service is the relation existing between it and the storage battery. Aside from its use in parallel with exciters, the storage battery has little application in a pure alternating-current system, for in order to use it in connection with alternating apparatus an outfit of motor-generators or rotary converters, rated at the discharge capacity of the battery at full load, must be installed as a connecting link. The storage battery has become a most important adjunct of the direct-current central station. The idea that its depreciation is very high in comparison with other power house apparatus, has largely given way in the face of modern guarantees of 6 per cent. maintenance over a long period of years, and the experience of the larger electric central stations as well as many smaller lighting, railway, and other power plants has shown beyond question the value of the battery as a reserve power and as a regulator.

The regulation of voltage possible from the central generating plant or sub-station in a system which is characterized by direct-current distribution is probably much better than the alternating plant can provide, on the whole. In electric lighting by direct current, hand regulation at the station enables the variations of the load to be closely followed, for the use of pressure wires from distribution centres gives an accurate idea of the potential at the consumers' lamps. There is no power factor to deal with, and the connection of different feeders with generators operated at slightly different voltages permits a maximum flexibility of adjustment.

The number of sub-stations necessary can often be reduced when alternating current is substituted for direct-current distribution, but it is almost out of the question to do away entirely with sub-stations and obtain first-class regulation at distribution centres. The substitution of transformers for rotaries or motor-generators at distributing points means a notable gain in operating efficiency and a decrease in the power house capacity required to deliver a given amount of power at the distribution centre, provided switches are installed at the primary sides of the transformers to cut out the core loss when the circuits are not in actual service. On a single transformer the core loss is, of course, a small matter in point of percentage of output, but when one multiplies, or better, integrates the value of the core losses over a wide area, the real cost of the transformer system becomes more apparent.

One of the most striking limitations of the alternating-current system of distribution is found in the difficulty of giving as good elevator service with it as with direct current, at least in the case of very high bulidings. The manufacturers of the alternating-current motor have made great progress in this direction, but so far very few plants have been installed for representative high-speed elevator service. They may come in time, and possibly much sooner

than is generally believed; but at present the slow or moderate-speed elevator serving the industrial establishment or the building of from five to ten stories is about the best which we find the alternating current capable of serving.

In outlying districts,—and it is there that we find many of the latest industrial plants,—there is undoubtedly a good field for the alternating-current elevator, and that is where most of the installations are being made just at present. A little later we may see the field extended, but at present the direct-current motor seems to enjoy the work of elevator driving in the larger installations to the practical exclusion of the later type.

To the central station the elevator problem is an exceedingly important one, for in the large cities the central station manager cannot drive out the isolated plant unless he can guarantee to supply the best quality of elevator service as well as light and power generally.

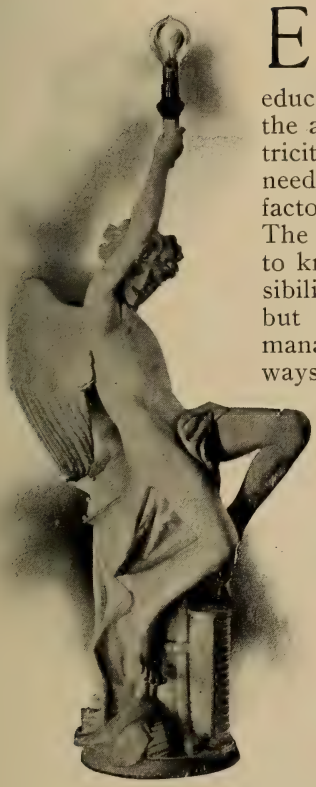
The whole question of extending alternating-current urban distribution hinges more upon the development of the single-phase motor than upon any other factor, but the question of retaining existing direct-current distribution systems is a much broader one, as we have seen.

One of the principal reasons why steam railways are so conservative in the matter of electrification is found in the enormous existing investment in steam locomotives. A close parallel is found in urban light and power distribution. To sum the whole question up, there is no intention today among progressive central station managers to refuse to employ alternating current when it can be shown that economy lies in its use; but as far as the conditions in the densely populated areas of large cities are concerned, transmission rather than distribution seems to be the natural application. On any specific system it is probable that one will find both kinds of current in economical use.

ELECTRIC CENTRAL STATION ADVERTISING

GETTING NEW BUSINESS

By Charles H. B. Chapin



ELECTRIC central station advertising means simply educating the public to the adaptability of electricity to the every-day needs of the office, the factory, and the home. The people really want to know about the possibilities of electricity, but the central station manager must devise ways and means of stimulating this curiosity and of making it current consuming.

When it comes to a question of business, of buying and selling, electricity is like every other commodity on the market. So much hard work was necessary to bring it to the practical service of every-day life, that the business side has been neglected. To-day, however, the case is different. Men with a knowledge of salesmanship are putting electric current on the market as a salable product. These men are succeeding deservedly, and yet there are many who are not alive to the ever increasing demand of the public.

What manufacturer, having five hundred customers on his books and the capacity to supply one thousand more, would instruct his factory superintendent to attend not only to the regular duties in the shop, but also to act as shipping clerk, collector, and salesman, and, relying altogether on this one man, should entirely neglect to advertise? The idea is absurd; yet there are many electric lighting companies doing exactly this thing, and whose managers are acting in all these capacities at once.

I recently visited a city of about 30,000 inhabitants, and inquired for the office of the municipal electric light plant. It was located on the second floor of a building on a side street. Upon calling at the office, I found it closed and the door locked, although it was the busy time of day,—about 11 o'clock. It was only after inquiry at the hotel and a small shop as to where bills could be paid and contracts signed, that I learned that possibly the manager was at the station about two miles away, and that the only way to reach him was to make an appointment by letter. In the face of this lack of ordinary business methods the municipality expects its electric light plant to pay.

Again, in a city claiming a population of over 400,000, one of the leading business men planned to build a residence in a fashionable district. Almost everything was under way, contracts had been let, and ground broken, yet he complained that no representative of the electric light company had called upon him to suggest the introduction of current into the new house. Being progressive, he called on the lighting company and asked that a wiring contractor be sent to him to

plan a perfect up-to-date installation.

In spite of such neglect the sales of electricity increase every year, indicating the possibilities that might be accomplished were central stations to push their sales departments with the energy devoted to creating and maintaining a perfect system,—in fact, applying the same general business principle that is devoted to this department in other lines of industry.

But in every business the advertising comes before the selling,—the placing before the public in attractive form of an idea, and then keeping it there. After this idea is firmly implanted, the salesman easily obtains an interview and finds a ready listener, and frequently a customer.

The large central stations have evolved a method which is bringing in results, and yet which is practicable only in large cities where it is impossible to reach prospective customers personally This plan consists of a department which works in conjunction with the salesmen. A list of every firm in each branch of business is filed on cards under separate headings. A man may be a possible user of electric current for lighting or power in its various phases. He is canvassed for every phase by letter, folder, picture postal card, illustrating some other establishment using the current in a manner suggestive to his needs, and finally a bright, readable magazine.

Of course, all of these suggestions are not sent at once, but at intervals, keeping his attention alive. Each clean-cut typewritten letter is accompanied by a return postal card, with the necessary form printed, so that the prospective customer has only to sign his name and mention a convenient hour when a salesman may see him to talk over the matter. Then the contract is almost the same as closed; but should the prospective new customer need further attention, the salesman reports to that effect, giving the follow-up department opportunity to use certain telling documents, which are forwarded to him from time to time. It is then simply a question of patience and persistently keeping after him. He will be convinced, sooner or later, and will finally sign a contract.

Private plant operators are subject to almost the same treatment. They are on a list by themselves, and every time the newspapers publish an account of a boiler explosion, each owner may receive a reproduction of this article, with fitting suggestions of how he can avoid the same danger. He may also be often reminded of how he can dispense with the annoyance and dirt of his plant.

In connection with this, the periodicals published by many central stations, usually designated as the "Bulletins," of the several stations, are far-reaching in their effects. Every month these bulletins publish pictures and details of some private plant shut-down, and mention the central station service adopted, giving convincing reasons for the change. This cannot help proving of interest to the private plant owner, and before he is conscious of it himself, he is becoming dissatisfied. At this stage the private plant man of the central station wins.

Prospective customers of electric signs are interested in a different manner. Attractive pictures are sent to them, and an occasional letter; but the first and most important step for the central station to take is to erect an attractive electric sign,—perhaps more than one,—to show that it believes in that method of advertising. This sign should be the best obtainable, and always operated at the highest efficiency.

One interesting example of this character is that of an electric light company in a city of about 40,000 people, which recently purchased a monogram or talking sign, and erected it in a prominent location on the main street. The work was com-

pleted and the sign ready for operation on the Saturday before Christmas,—a particularly propitious time to start an exhibit of this kind, as the street crowds were naturally larger than usual.

When the first word flashed out, people stopped to watch, and by the time the company had wished them a "Merry Christmas," a large crowd had gathered, which cheered enthusiastically. Finally, the assistance of the police was necessary to keep the street clear for the trolleys. The show lasted all evening, and was the one topic of conversation among the shoppers. On Sunday, the day after, the manager states, he received many telephone messages at his residence congratulating him on his success.

A further use to which this same sign is to be put is both interesting and novel. The manager noticed, on sending out the January bills, that several of his best customers had charges beyond the average, which, although due to the holiday season, promised to result in complaint and dissatisfaction. He immediately called on these people and offered to each of them, without charge, the use of his sign for one evening during the coming month. They were naturally much pleased. Two important results were thus accomplished, —a dissatisfied customer was converted into an ardent advocate of the company, and was led also to see the possibilities of advertising by an electric sign. As there is no better advertisement than a satisfied customer, the success of the talking sign experiment was assured.

Although it seems unnecessary to say anything about it,—as it would naturally be the first thing an electric light company would do,—it is astonishing to note how few companies realize the possibilities of advertising by means of their own well-lighted show-windows and offices. Every one is watching for something attractive, and what can attract more attention than a well-lighted window and show-room. This method is more adaptable to central stations in the smaller cities.

In a city having a population of 50,000 a bulletin like those just mentioned would be impracticable; the people can be reached better and more directly by display and newspaper publicity.

Many of the larger electric light companies maintain show-rooms where various pieces of machinery are exhibited, driven by electric power; demonstrations are given in electric cooking, and different methods are illustrated of illuminating show-windows, and many other interesting and novel ways of employing electric current. A large display is not needed, nor is such a display possible for every electric light station; yet each can have a display in a modified form and one which will reach its possible customers.

To return to the question of the follow-up letter, it may be said that the persistent use of personal letters is probably one of the most successful methods of advertising, although the direct results, that is, the contracts signed and directly traceable to the letters, may not come up to expectations. If the letters are not too long, but are made up of short paragraphs, they will be read, and the reader will have received an idea whether he wants to or not. That idea will grow, and, with future letters, will become more firmly fixed, being helped along, too, by other suggestions. In time, a new customer may be the result; but it will require patience, and even when he has signed a contract, he may deny emphatically that he was in any way influenced by the letters.

The growth of the idea is well illustrated by the statement of a very large advertising firm that it often requires a year, and sometimes two years, after the matter is first brought to a man's attention, to convince him that his business may be increased, for example, by means of an electric sign. In the meantime,

however, he has been noticing such signs from an entirely different standpoint than prior to the birth of the idea.

A large electric light company reports that it considers the follow-up system a success after a trial of a little over a year. Directly traceable to the follow-up department are found sales of current for a great number of different uses besides that of general lighting and power. Signs, fans, heating apparatus, including plate warmers, stoves, water cups, foot-warmers, heating pads, irons, and chafing dishes, are all mentioned as among visible results, while the unusual increase in contracts during the past year is ascribed partly to the advertising which has been done and of which the follow-up system is an important part.

The points which may be covered by these letters are so numerous that it is impossible to mention more than a few. In the case of residences, erroneous ideas as to the cost of wiring should be corrected; the many conveniences of electricity in the home should be brought out, such as lights in closets and on the porch, and the possibility of turning off the lights downstairs by a switch on the second floor. This latter should be shown to be not only a convenience, but a great protection against burglars. Then, further, there are the points of safety and health, and the adaptability of electric light to decoration.

For business houses some of these arguments apply, but to them should be added a discussion of the superior colour effects obtained from arc or Nernst lamps, as compared with those of other illuminants.

Under the head of advertising should be included sign and show-window lighting, and it can readily be proved how much better results may be obtained by the customer in this way than by buying space in the newspapers or by any other method. It is desirable to have different forms for different lines of business, and the system may be extended almost indefinitely in this way.

Central station managers are always particularly anxious to increase their power load, and the follow-up letter may be used to this end very advantageously. The adaptability of the motor to practically any power conditions, the low cost of making extensions,—merely the expense of an additional motor perhaps,—the possibility of overtime work in one department without the necessity of keeping the whole plant running, the absence of shafting and belting and the consequent saving in wasted power, the safety and convenience, no dirt or dust and no oil dropping from overhead bearings, are a few of the many advantages which should be placed before the prospective customer.

A form of advertising as a means of keeping old customers awake as to every new use of electric current, is an attractive folder or small blotter enclosed with the monthly bill. This kind of publicity is inexpensive, as there is no extra postage. The message reaches the people whom you wish to interest, and often leads to increased use of the service. If these folders and blotters are kept in the office on view, every visitor carries off one or two. In this way, again, is the question of distribution of the company's literature settled.

All of this direct advertising brings us to the point of general publicity,—newspaper advertising. Many advertising agents favour newspaper advertising of the general subject, not the company; that is, they favour omitting the name of the advertiser. This method is especially applicable to central station work, as in the great majority of communities there is only one supply company in the town.

An example of a unique method of newspaper advertising is given on the opposite page.

The electric light company buys regularly a certain amount of space,

DID you ever buy a suit of clothes in the evening and think you were getting one colour, only to find it another when examining it at home by daylight? The fault, of course, was in the illumination of the store—probably the salesman himself couldn't tell the real colour.

¶ Blank & Co., Clothiers, at 26-28 Court Street, use our brilliant electrics. No danger in being mistaken in colours there.

Consult us about anything concerning
ELECTRICITY

Blankville Light, Heat & Power Co.

thus making a friend of the newspaper, and in some cases a good customer. This space is then used not only to advertise the company, but, as will be seen, a combination is obtained by which customers get free advertising and the company is allowed to refer to these model installations.

This method has met with great success; the customers are pleased, and always take pains to say a good word for the company. The newspapers are favourable, and the central station itself has advertised in such a way that persons going to the shops mentioned will notice the lighting, and other shop-keepers who have not been so progressive will feel prompted to become customers.

The company previously referred to when describing the effects of the talking or monogram sign, uses this clever system. The manager writes regarding it as follows:—

"As you probably know, we handle considerable space in the daily papers, in which space we advertise our customers, calling attention to any special articles that they wish to have featured, and also calling attention to the lighting of the store, —in other words, making a combination advertisement which in all cases is as much to the customer's advantage as our own. This has worked very satisfactorily, and has been of considerable assistance to us in increasing our current output. We also talk in the papers about the monogram sign, and refer on the sign to the daily advertisements in the papers.

Working the two in conjunction, we are getting, I think, splendid results."

Referring later in the letter to the advertising of customers on the monogram sign, he says:—

"This is also working out very well. We have been able to close some business by giving space on the sign that we otherwise would have undoubtedly lost."

Still further on, after discussing some of the difficulties of selling current in a small city, which are not encountered in a large one, he sums up the results obtained in this sentence:—

"Our gratifying increase in net profit this year is proof that our educational methods are bringing fruit."

THE UTILIZATION OF NATURAL ENERGY

By Dr. Louis Bell

While Dr. Bell illustrates his article with American examples, the application of his remarks is general. The menace which lies in the depletion of material resources is present in all civilized countries.

TO the reflective mind there is a singular fascination in casting forward to apprehend, if may be, something of the conditions of human life and industry a few centuries hence. We are generally too apt to jump at conclusions in these prophetic incursions and to assume that because the nineteenth century was a period of unequalled material and intellectual activity, the twentieth and twenty-first centuries will, in their turn, carry forward industry and invention to a height that will dizzy the imagination. But if history teaches anything, it is that there has never been uninterrupted progress in any particular direction for any great length of time. The golden age of Greece, with its splendid achievements; the apparently resistless sweep of Roman prosperity under the Empire; the subtle forces of the Italian Renaissance a thousand years later, came comet-like out of the blackness of space and to it again returned, leaving, it is true, glorious memories, but themselves fading from sight.

There are no data from which to judge the probable length of these flaming outbursts of activity; they may endure one century or several, though there is no valid reason for expecting any one of them to become a permanent luminary of human civilization. Doubtless the Roman governors of Britain believed that they had brought to benighted barbarians the splendid permanence of Roman institutions, although their villas, temples, and tombs have been forgotten for ten centuries save when now and then unearthed by the prying fingers of the curious archeologist.

One is not then justified in going optimistically along building the future according to his heart's desire. Even now there are forces at work that tend to the repression of much that we have comfortably regarded as a settled part of the present dispensation. To the evaluation of some of these the present paper is directed.

Those to be here considered affect merely the material and physical side of the situation, which is perhaps the most hopeful one. They may be classified under the general head of the rapid local depletion of natural resources, local being here used in the larger sense rather than as merely pertaining to small districts. During the past hundred years the world's inherited stores of valuable material have been subject to inroads such as could hardly have been imagined in previous centuries.

Every labour-saving improvement tends to transfer the demands of humanity from current expense to the capital account which is not replenishable, and with all the increase of material prosperity the inorganic materials of prosperity are steadily diminishing. The direct losses are in part compensated by improved means of utilization and of transportation, themselves, however, often entailing heavy draughts on a different part of the capital account; and con-

tinually increasing demand more than keeps pace with the laboriously increased supply.

One does not have to look far for examples. Many of the metals are already strongly affected in price by the increasing difficulty of obtaining an adequate supply. Tin, lead, and copper are at present produced in insufficient quantities to supply the enhanced demand, and, discount the situation as one may on the ground of temporarily abnormal prices, the fact remains that the relative supply is insufficient. In the case of the first-named, the mines which for many years supplied the world's needs are no longer adequate, and while doubtless other deposits will be found, no one at present knows their location or magnitude. Lead and copper are similarly affected in less degree, these metals being widely distributed, but subject to increasing cost of production owing to the necessity of working less advantageous supplies in order to keep up with the demand.

Another case in point is platinum, which has almost quadrupled in cost during the past quarter of a century. No new sources of much importance have been found, and while the existing stock is conserved as far as possible by reclaiming whatever can be saved, unless a plentiful new supply is found or the present demand greatly diminishes, a few score years will bring a very serious scarcity. Nickel is another metal which is very likely to be affected in a somewhat similar way. Even iron, the commonest of the metals, cannot be mined with steam shovels at the present rate for more than a few generations, and while enormous deposits are available, any considerable appreciation in value owing to difficulty of mining or to greatly increased transportation charges, would be, from our present standpoint, a world calamity.

Fancy, for example, the conditions that would be produced in modern civilization were iron at $100 a ton or such conventional figure as would correspond to that price at present. We know of no substitute for iron for use on a large scale, and any large increase of value would reflect most disastrously on manifold branches of industry. Yet this state of things, so far as the present civilized world is concerned, is not only imaginable, but highly probable within a space of time short as time is counted in the life of nations.

Still more directly serious is the depletion of the fuel supply, of which the writer has often had occasion to speak. Of that supply the attack upon the irreplaceable portion stored in the carboniferous age has been already so fierce as to have produced very conspicuous results. Anthracite has even now become too scarce for profitable use for most industrial purposes, and its price is rising at a rate that will make it within the lifetime of men now living an interesting luxury as cannel coal is to-day.

The stores of bituminous coal are vastly greater, but still the deposits now known are exhaustible within a few hundred years, even at the present rate of consumption, and if large new fields are found, there is every probability that they will be in regions very remote from the world's present centers of industry, and so subject to huge transportation charges. Add to our hypothetical iron at $100 a ton ordinary steam coal at $10 a ton and imagine, if you can, what the net effect on the world's work would be.

Natural gas in its original district has already been to no small extent exhausted, and while both it and petroleum have been found in quantity elsewhere, it is only a question of time when these localities too will feel the effects of tremendous draughts on an exhaustible supply.

In addition to all this, so furious an assault has the last century made upon supplies which, like timber, are replaceable, that the visible supply has been very greatly reduced so that it will take many years of deter-

FIG. 1.—MAP SHOWING THE FIVE PRINCIPAL WATER-POWER REGIONS OF THE UNITED STATES

mined effort to bring it back to the point of giving a reasonable amount, even within a decade or two, for not immoderate demands. So rapidly has the work of destruction gone on that the price of lumber for ordinary uses has very greatly risen, carrying with it the prices of everything for which lumber is necessary. Very strenuous efforts are now being made to check this wholesale destruction and to encourage a policy of systematic replacement. So strong, however, is the reverence, in most places, for vested interests, and so great the temptation of steadily rising prices, that any permanent work in forest replacement is unlikely to be carried out on a large scale until the situation grows even more desperate than it now is.

What does all this signify, and what can be done to check the self-destructive forces that have grown with the achievements of the century gone? If nothing is done and things go on as at present, the gradual exhaustion of stored resources and the consequent increase of costs will be very severely felt in a few generations. In particular, the depletion of the fuel supply will make the struggle for existence in the north temperate zone, which is now the main seat of the world's activities, a battle against desperate odds, at least in its more northern portions.

The rational remedy which humanity must sooner or later apply, is greater dependence on renewable energy and material, and the utilization of material not now freely employed. A beginning has already been made in the more economical use of fuel, intelligent forestry, and in the rapidly extending utilization of water power; but far more must be done in these directions if anything of great importance is to be achieved.

The natural sources of energy available for the world's use are water power, wind power, and tidal power, together with the fuel that grows. To these we may add the solar heat, which is capable of direct utilization on a very large scale in multifarious ways. Of these sources of energy water power is of by far the greatest present importance, increased in practical value by the ease with which it can be electrically transmitted. If water power were at all uniformly distributed, it would in great measure relieve one of any fears as to the supply of energy for ordinary manufacturing purposes and for land transportation. Heating in a cold climate, however, is quite another matter. So long as civilized man insists on living in climates fitted only for fur-bearing animals, he must pay the penalty in full. The whole power of Niagara would hardly suffice to heat a city like Greater New York.

Natural water power is unfortunately a matter of topography and exists in considerable amounts only where steep gradients are associated with considerable precipitation. This condition very greatly limits the regions which are rich in water power, and limits them also to regions which in other respects are not generally suited to the support of a large population. There are in the United States five principal water-power regions which are roughly indicated on the map shown in Fig. 1. There are water powers, to be sure, in nearly every part of the country, but outside of the areas indicated they are comparatively scarce and mostly unimportant. Within the shaded areas may be found a very large proportion of the available powers of the country. The New England area is the most developed and, in some respects, the most advantageous, since the region abounds in lakes capable of furnishing large natural storage. Moreover, the eastern part of the district has a rainfall exceeding 40 inches per annum.

The Appalachian power area is as yet slightly developed, although in the past few years a good beginning has been made. It is a region of heavy rainfall, exceeding 50 inches

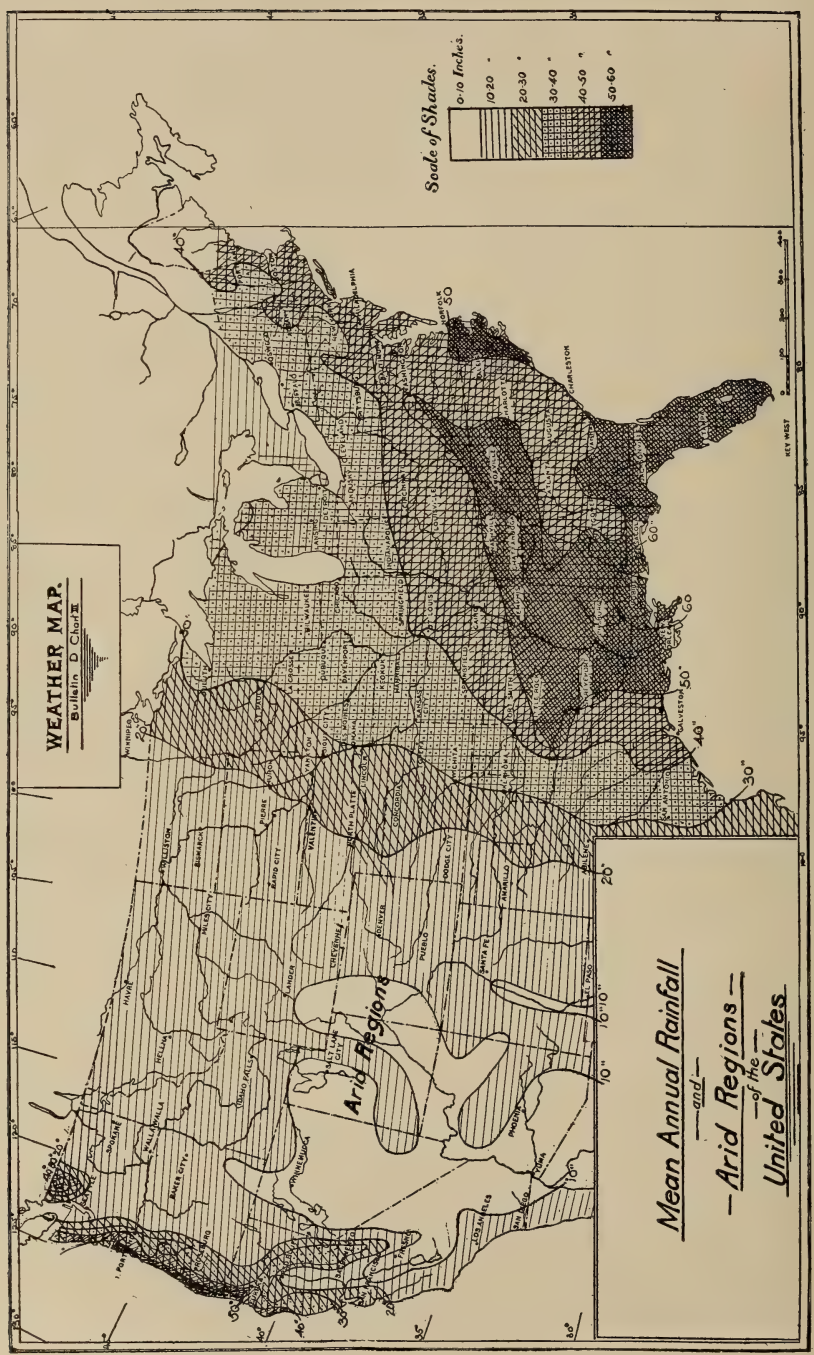


FIG. 2.—A RAINFALL MAP OF THE UNITED STATES

per annum in parts, and is rich in streams. But it is characterized by the almost total absence of lakes, so that whatever storage is obtained there must be artificial. The region shades off eastward toward the sea, so that there are quite a few low-head powers outside the main area, some of which have been utilized. It is an interesting and profitable field for hydraulic enterprise.

Westward, in the upper Lake region lies another district where water powers, mostly small and of moderate head, are rather common. It shades off southward and westward into prairie land which stretches out for seven or eight hundred miles before one again reaches a region of sharp gradients favourable for hydraulic developments.

The Rocky Mountain area I have indicated with some hesitancy. It contains many powers, but there are districts within the shaded area almost bare of them and others which have been insufficiently explored for hydraulic purposes. The rainfall all over the district is low, nowhere perhaps reaching 20 inches per annum, and the best streams are those fed from the snow of the higher peaks. The streams, as a whole, are subject to great variations of flow and there is almost no natural storage. But the heads generally are high, and within the district there have been some important and interesting power developments, especially in the quarter near the Great Salt Lake.

The Pacific Coast power area is a large and well developed one. It lies along the Sierras, running nearly north and south in a rather narrow belt, broken near the extreme southern end by the Mojave desert. It is a country of very high heads for the most part, on mountain streams showing enormous variations of flow, those in the northern part of the belt being considerably the more reliable. Any one familiar with electrical power transmission realizes the very important part which this coast district has played in the art. Storage when obtained here must generally be artificial.

The areas as shown are only approximations, but they serve at least to display the conspicuous fact that the greater part of the United States is devoid of any considerable hydraulic resources, especially in the portions most valuable for agricultural purposes. The Pacific Coast region is the one best off in this particular, all of that splendid country being within easy transmission distance of the available water powers.

Great potential possibilities, however, lie in the Appalachian region, with its large rainfall and the rich country that lies about it within very practicable distance for electric transmission. Here and elsewhere the full significance of the value of rainfall is little appreciated. The absolute amount of energy furnished by the normal rainfall is very great, but owing to dependence on purely natural conditions, most of it is wasted. We generally take such proportion of the rainfall as Nature gives us, utilize part of it, and let the rest run to waste. Even at present prices of fuel this careless procedure is generally unwise, and when a serious attempt is made to conserve the fuel supply, very different methods will have to be adopted.

As a starting point in hydraulic economy, an easy figure to remember is that 1 acre, stored 1 foot deep with water, utilized by wheels of 80 per cent. efficiency, will produce 1.1 horse-power-hours for each foot of available head. Obviously, the thing to look for is a chance for storage at high head in order to get as much as possible out of the water stored. At 1.1 horse-power per acre-foot, under, say, 500 feet effective head, a 1000-acre pond, stored 10 feet deep, would produce 5,500,000 horse-power-hours, which would yield over 1800 horse-power steadily for a working year of 3000 hours; or, if applied to an electric transmission plant, with its variable load through

the 24 hours, would be equivalent to a station of about 2000-KW. capacity.

The storage of this amount of water requires a watershed enough larger than the pond to fill it annually in spite of the ordinary losses from seepage and evaporation. Granted this, the reservoir will serve as a continuous source of power quite irrespective of the flow of any original stream, becoming thus an artificial source of steady power.

The feasibility of such storage evidently depends on the contour of the country, the rainfall, and the amount of the losses above referred to. Fig. 2 gives a rainfall map of the United States. The annual amount ranges from a normal of about 3 inches at Yuma, Ariz., to more than 60 inches. The favourable combination of a mountainous country and heavy rainfall occurs in two regions, the Appalachian district and the Coast Range. The latter should be included in the Coast power area to which it properly belongs, although its streams are very little developed as yet.

The Rocky Mountain region has so scant rainfall that its power opportunities are limited, though sometimes locally valuable. All such relatively dry regions are also handicapped by increased evaporation.

Of the total rainfall, roughly, one-third can be reckoned as finding its way to the streams. In case of a limited watershed, such as we are here considering, this proportion is considerably increased owing to the short distance of the run-off. In the Chittenden, Vt., power reservoir, which is one of the very kind in question, nearly 70 per cent. of the rainfall has been found to reach the reservoir, which has, by the way, very nearly the same storage capacity here described.

If one-half the rainfall could be reckoned as going into storage, a region of, say, 48 inches annual fall, would demand only 5000 acres of watershed to fill the 1000-acre pond annually. Evaporation, however, must be taken into account, and it is a much larger item than is usually supposed. The hotter and drier the climate and the greater the surface exposed, the greater the relative loss. For an approximation the watershed area should be increased 50 per cent. to allow for evaporation, and a still further increase would be necessary on account of years of abnormally low rainfall.

In a comparatively hot and dry climate the yearly evaporation from a surface would run as high as 6 or 8 feet, so that the advantage of a deep storage pond is obvious. One would not go far wrong in counting on a watershed ten times the pond area for the depth assumed in this case, and proportionately more for a deeper pond. In the Chittenden case the pond is 800 acres and the drainage area nearly 10,000.

Of course, the cost of artificial storage is high, but for power purposes it is much less than in the case of ordinary water supply, since first, the necessary head requires storage in a mountainous country where the land is generally of very little value for other purposes; and second, because the watershed does not for sanitary reasons have to be withdrawn from use.

The cost of such a storage operation is likely to be somewhat higher than the cost of natural hydraulic rights under similar topographical conditions; but, on the other hand, may easily be lower than hydraulic rights on obviously useful streams. The scheme is merely an extension of the ordinary case of hydraulic storage to the case where the natural flow of the stream is negligibly small.

Tidal storage has often been proposed as a source of hydraulic power, and in fact tide mills were, and still are, occasionally found in favourable locations along the coast, usually on a small scale. The system has two weak points,—the small rise and fall of the tides in most situa-

tions, resulting in low available head, and the periodic nature of the flow, demanding some special provisions for storage of power, quite apart from merely impounding the water. In addition one has to struggle with the vexatious problem of operation under variable head. Localities in which there is a large tidal rise under conditions favourable for storage are very few. Perhaps the Bay of Fundy, where the rise is 40 feet, furnishes the only one on the American Continent which would be worth serious consideration for work on a large scale.

Wave motors have been occasionally used, but here, as in the case of tides, the power is irregular and very difficult to obtain on anything but a very small scale. In short, whatever help can be obtained from the ocean can be relied on only locally and to a minor extent. In the days of scarce coal such power would certainly be used, although unimportant as a general resource.

Wind power, from its general distribution is a far more valuable auxiliary than tide or waves. The chief objection to it practically is its uncertainty in amount and the variable speed of the motor itself. Under stress of necessity there is little doubt that the regulation difficulty would be, in great measure, overcome so as to give practically uniform speed over a pretty wide range of wind pressure.

The average velocity of the wind is low, in most places between 5 and 10 miles an hour, corresponding, respectively, to wind pressures of from 2 to 8 ounces per square foot. These are too low to be conveniently utilized, on account of the large dimensions demanded in the motors. During portions of nearly every day, however, somewhat higher velocities are recorded, since the averages contain considerable periods of very light breezes occurring often within a few hours before and after sunrise and sunset. Hence, there are few days without periods of brisk breezes of from 15 to 20 miles an hour, giving wind pressures of from 1 to 2 pounds per square foot. On the other hand, winds exceeding 30 miles an hour (4.4 pounds per square foot) are sufficiently rare to be the subject of special record in the Weather Bureau.

An effective wind motor should be able to work at good advantage up to, say, 5 pounds per square foot pressure at fairly uniform speed, and should be robust enough to stand up against winds of 50 or 60 miles an hour without going by the board. For certain uses, such as pumping, speed regulation is not necessary, but if wind power is to be included as a resource in the general power situation, even on a small scale, regulation is necessary, and it has thus far been carried out only to a very limited extent.

It is probable that the winds may be relied upon for the ordinary uses of our agricultural community, although they do not form, save in the region of the trades, anything like a reliable source of power. For the larger work of power production they cannot well be regarded as important, and in certain districts they are too unreliable even for casual use.

Eliminating the winds, therefore, the chief available source of energy on a large scale, other than hydraulic, is solar radiation as such. The full mechanical equivalent of solar radiation is something like 10,000 horsepower per acre of surface exposed to the perpendicular rays of the sun. But in these latitudes not only does the sun run rather low, even at noon, but in the morning and evening remains for several hours at so low an altitude that there is very great loss from atmospheric absorption. Hence the prodigious figure just given must be very heavily discounted in temperate regions. Besides, clouds often intervene so that sun power is not continuously available even during the hours of daylight.

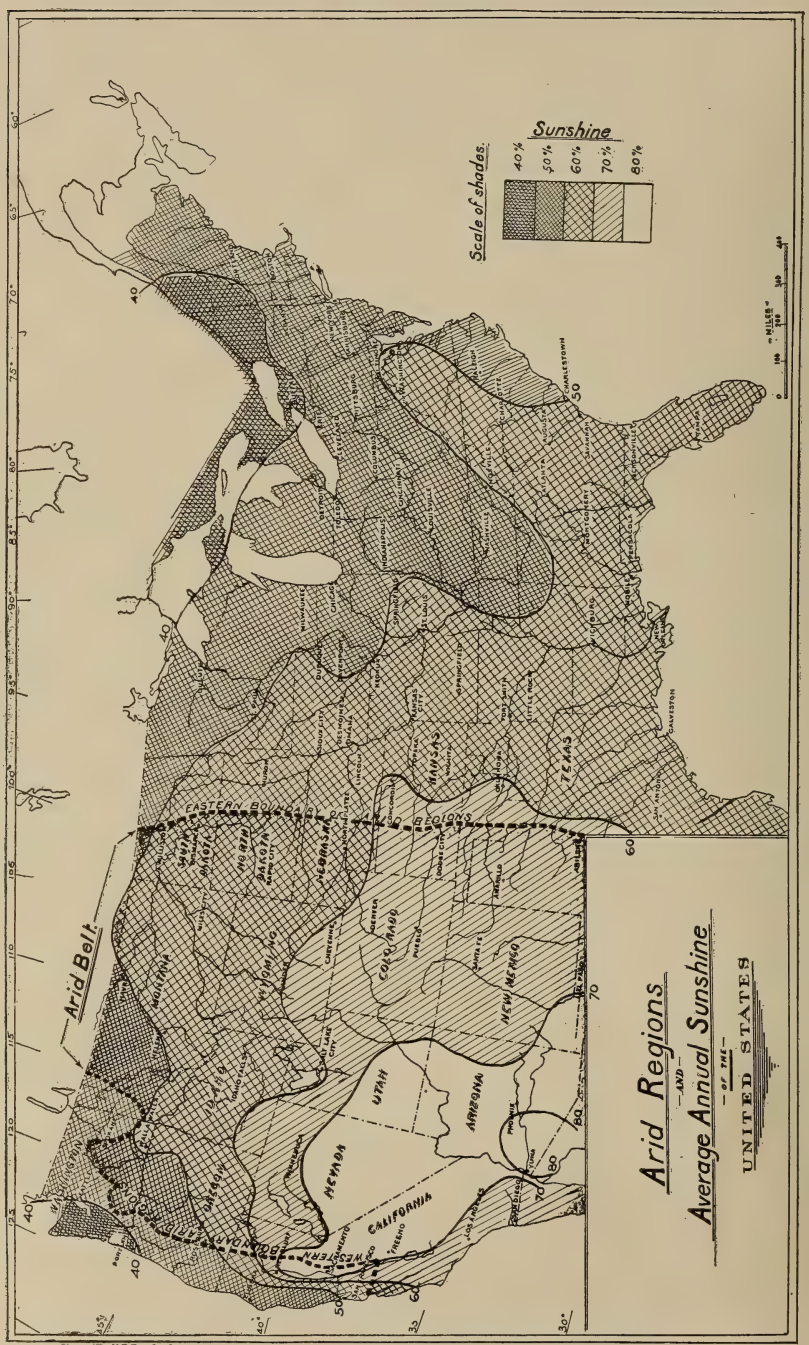


FIG. 3.—A SUNSHINE MAP OF THE UNITED STATES

FIG. 4.—A 10-H P. SOLAR MOTOR PUMP FLOODING A FIELD ON AN ARIZONA RANCH

Fortunately in regions where rainfall is light and hydraulic resources are meagre, the sunshine is apt to be relatively reliable. Fig. 3 gives a sunshine map of the United States, from which it will readily be seen that the whole arid region of the West is a district of from 70 to more than 80 per cent. of sunshine. Most of this belt is wonderfully fertile when irrigated as it some day will be, and could support a dense population, and there, if anywhere, some of the possibilities of solar power can be realized.

The work of Ericsson and of M. Mouchot more than a quarter of a century ago demonstrated that under practical conditions a mirror surface of 100 square feet, used to heat the boiler of an engine, would yield one horse-power for 8 or 10 hours a day. To accomplish this, the machine must be turned fairly toward the sun and must effectively concentrate the solar rays upon the boiler. Within the past few years there has been a systematic attempt to develop a solar motor which has met with a rather encouraging degree of success, having shown definitely that work can be thus done under usual commercial conditions.

Obviously, a true concave or parabolic mirror of the requisite dimensions would be prohibitively costly, and fortunately it is neither necessary nor desirable, since the focus is not to be a point, but the surface of a boiler. The plan actually followed is to build up a parabolic structure of plane rectangles, so disposed that each throws the solar image fairly upon the boiler. This is, oddly enough, closely akin to the disposition reputed to have been used by Archimedes in burning the hostile fleet, and which certainly was used successfully by Buffon more than a century and a half ago to ignite wood 200 feet distant. But in this case the heating is at very short range and the apparatus is in form something like a huge umbrella with silvered glass on the inside, and a boiler for the very short handle, turned always toward the sun. The reflector, therefore, is carried on a polar axis, about which it is automatically turned so as to follow the sun.

Motors of this sort have been made up to 10 or 15 H. P. output from the attached steam engine, beyond

which size the mirror system becomes rather too unwieldly. The maximum output is not far from one horse-power per 100 square feet of mirror surface, when the sun is near the meridian. The practical application of the apparatus has thus far been in pumping water for irrigation. Fig. 4 shows a 10-H. P. motor of this kind at work flooding a field on an Arizona ranch where fuel is costly and wind power would prove insufficient. The mirror system and its support is seen in the background while the flow is flooding the foreground.

Obviously the motor is capable also of use for general small power purposes, and if necessary a group could be coupled electrically so as to furnish power on a somewhat larger scale. This line of work is within limits rather promising and can be carried on to advantage in the arid regions generally. It is a steam plant, with the sun for a furnace, and the fuel bill therefore eliminated, the expense appearing almost entirely as fixed and maintenance charges.

Similar apparatus on a much smaller scale has been successfully applied to cooking, to which in some climates it would seem to be well adapted. At a pinch, heat thus obtained could be stored for ordinary heating purposes, so that in case of need the world can obtain directly from solar radiation heat and power enough to get along pretty comfortably, except in a very densely populated region in a cold climate. When the fuel supply runs low, as sooner or later it must, there will certainly be a tendency for the population to drift away from rigorous climates toward those in which the struggle for existence may be less acute.

The natural sources of energy here considered are not easily available for the use of great centers of population at the points where these at present exist. In case of failure or serious curtailment of the fuel supply, New York, Chicago, Philadelphia, London, Paris, Berlin, Vienna and St. Petersburg, to say nothing of scores of cities below the million mark, would become practically untenable, and no natural sources of energy are available to an extent sufficient to save them. But these natural sources, if intelligently utilized, are sufficient to keep the world's industries moving if so redistributed as to employ them to advantage.

A more serious menace lies in the depletion of other material resources that are not replenishable. Two great continents are now, however, practically undeveloped, and the employment of new materials will go far to compensate for the loss of old ones.

But natural sources of energy the world must learn to utilize to the fullest, to prevent needless and wasteful shifting of industrial activity.

THE SUCTION GAS PRODUCER

By W. H. Booth

Concluded from the March Number

ANTHRACITE is undoubtedly the most facile fuel for producer work, and suction producers have hardly been attempted except with fuel of a fairly dry order which will not cake and offer obstruction to the passage of air through it. According to Thwaite, a bituminous coal for a suction producer should not exceed 15 per cent. of volatile matter. In such a producer the burning must be downwards, the green fuel being put in at the top where it gives off its gases; these pass down through the hot fuel below, but this is not sufficiently hot to convert the volatile matter into fixed gas. To ensure this action, there is a secondary supply of air, admitted at a short distance down. This produces a second zone of high temperature which serves to fix the hydrocarbon vapours and destroy the tarry matters. Below this zone the producer is of the ordinary type.

The difficulty with bituminous fuel, apart from its caking and clogging property, is that the distillation of gas absorbs so much latent heat that there is risk of an insufficient temperature for the complete conversion of all the CO_2 into CO. Hence Thwaite's use of the secondary air supply, to raise the fuel to incandescence for the purpose of splitting up the hydrocarbons and fixing them as gas.

The suction producer of the Masons Gas Power Company, Ltd., of London, is shown in Fig. 10. The makers state that with fuel at 20s. per ton, about 14 I. H. P. can be produced for 1 penny per hour. It differs essentially in no way from other producers, and is started by a hand fan shown in the illustration. A sawdust filter is used in the course of the purification to catch any final dust or tar.

The Crossley suction producer, shown in Figs. 11 and 12, consists of the usual firebrick shell with an outer iron shell and a sand-filled space between. The lining rests on a cast iron hollow ring-box, called the superheater, which stands on a flat plate, the middle of which is cut away and closed by the grate. Through the superheater arrive the steam and air from the vapourizer which surrounds the fuel feeder bell and extends over the whole top of the producer. The feed-water enters at the bottom of the deep annular portion, and the escaping gas is compelled to take a circuitous course under the flat portion of the vapourizer before it can escape to the scrubbers.

Steam passes down two vertical pipes to the superheater, whence it escapes to the space above the base plate, together with air, before entering among the fuel in the firebrick portion above. Seven-eighths of a pound of fuel per B. H. P.-hour are said to be sufficient.

The scrubber employed is, as shown, a double tower, the gas passing down the first and up the second tower. They are coke-filled, as usual. The American Crossley producer shown in Fig. 13 is substantially constructed on the same general lines as its English prototype, with hand-worked starting fan, float-feed vapourizer, annular steam superheater M, and grate.

As with the English pattern, a portion of the air enters by the cock

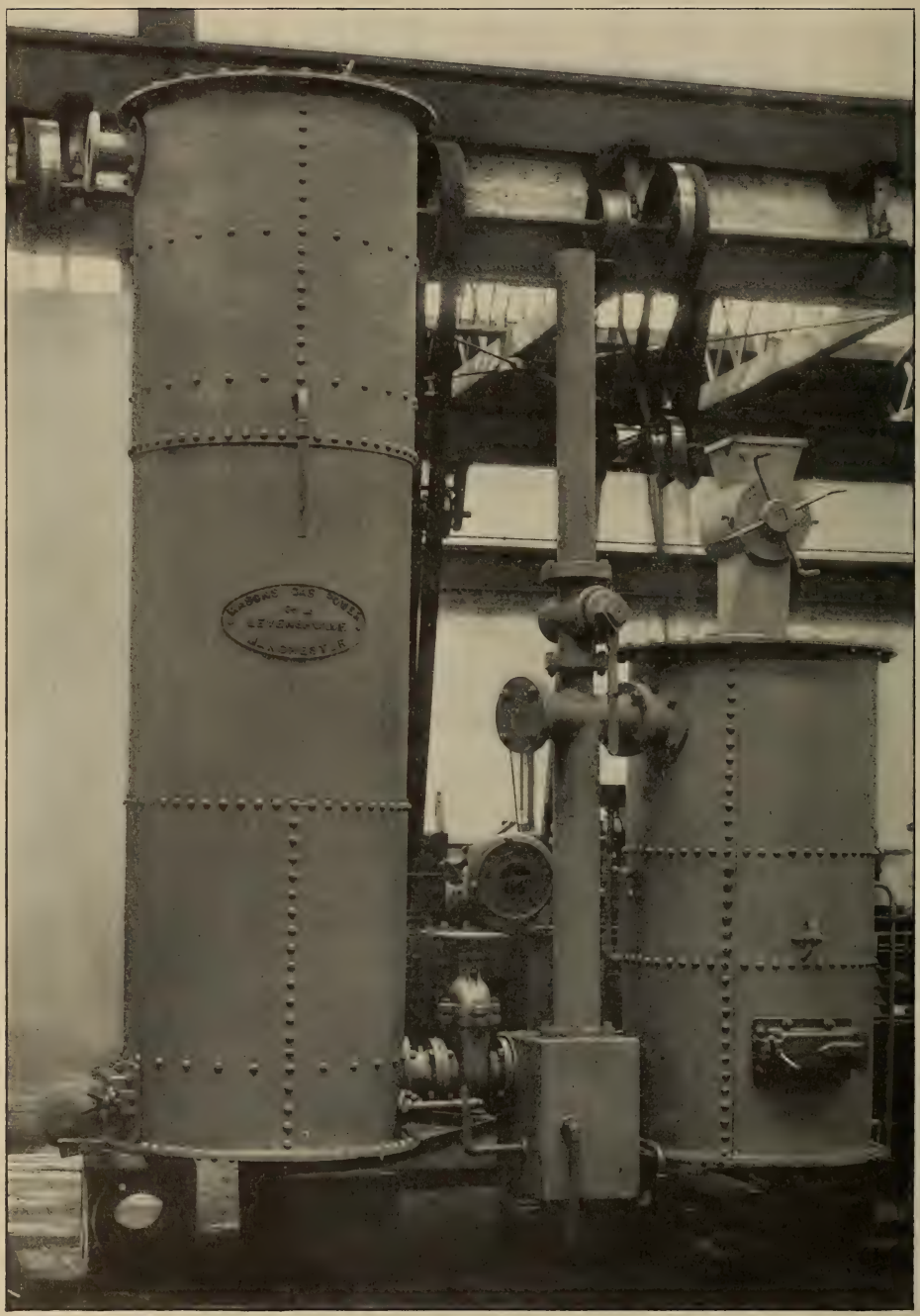


FIG 10.—A SUCTION PRODUCER MADE BY THE MASONS GAS POWER COMPANY, LTD., MANCHESTER

K on the vapourizer and becomes charged with steam. Fuel enters by an air trap *C* and is stored in *B* in sufficient quantity for several hours' run. The grate *A* can be shaken to reduce clinker by means of the lever seen on the left of the superheater *M*. Poke holes *H* are provided at the top for poking the fire should it hang up. A valve *P* serves, with *K*, to regulate the two supplies of air.

The annexed table of comparative costs of fuel per B. H. P.-hour with different engines may be translated into English on the basis of 2 cents equal 1 penny and $5 equal £1 sterling. Apart from fuel economy, the gas producer requires but little labour and not much careful attention, no serious results accruing from neglect such as may happen if the feed to a steam boiler is neglected.

RELATIVE COSTS OF FUEL WITH DIFFERENT TYPES OF ENGINES

Type of engine.	Class of fuel.	Price of fuel.	Fuel consumed per B.H.P. per hour.	Cost in cents per B.H.P. per hour.	Cost per annum 3000 hours per 100 B.H.P.
Simple non-condensing slide valve..	Bituminous coal	$3.00 per gross ton.	5 lb.	0.669	$2,007.00
Compound condensing.....	Bituminous coal	$3.00	3 lb.	0.402	1,205.00
Steam turbine.....	Bituminous coal	$3.00	3 lb.	0.402	1,205.00
Oil engine.....	Gasoline	14 cents per gallon.	0.125 gal.	1.75	5,250.00
Oil engine.....	Crude oil	4 cents per gallon.	0.10 gal.	0.40	1,200.00
Gas engine.....	Illuminating gas	75 cents per 1000 cu. ft.	19 cu. ft.	1.425	4,275.00
Gas engine.....	Natural gas	20 cents per 1000 cu. ft.	13 cu. ft.	0.26	780.00
Gas engine with suction producer...	Anthracite coal	$3.00 per gross ton	1 lb.	0.134	402.00
Gas engine with suction producer...	Coke	$3,000 per gross ton	1.25 lb.	0.167	502.00

It is perhaps too early to state definitely what is the rate of depreciation to be allowed in suction producers, but since there is no danger from high pressure, the metal work need not be considered worn out until it becomes actually perforated by corrosion. There is, however, no apparent reason why there should be much corrosion. The brick lining is exposed to wear and tear, but can be readily renewed, and the vapourizers may perhaps become incrusted. Still one would not anticipate serious depreciation charges.

The suction producer is, par excellence, the plant of the small power user. It finds its best field in the works of the small man. If gas is needed for heating purposes, the suction producer alone cannot give it, but it can be obtained by the aid of some draught apparatus, such as a pair of holder or bell vessels, hung on either end of an oscillating beam, drawing gas from the gas box, and delivering to a small weighted supply holder. The Whitfield Company use a steam inspirator to propel the gas forward.

During the year 1905, the Highland and Agricultural Society of Scotland carried out a series of tests with suction gas producer plants in order to enable members to become acquainted with the combination of suction producers with gas engines, as well as to demonstrate the utility of the producer.

The trials were arranged as nearly as possible under working conditions. Each firm competing was requested to furnish two separate plants, one of 15 to 20 B. H. P., the other of 5 to 8 B. H. P. Prices were to be given. From the report it appears that suction producers can be obtained for about £4 per B. H. P. of 20 to 25 B. H. P. capacity. The smaller producers cost from £5 to £6 for sizes of 10 to 12 B. H. P., and one plant of 8 B. H. P. cost £10 per B. H. P. The trials were made with pea anthracite at a cost of 9s. 3d. per ton, and no difficulty was experienced with it. Only two

men were allowed to attend any plant. An average of about 15 minutes was required for starting a producer from rest, empty and cold. No serious failures occurred, very little attention was required, and there was no serious difficulty in any of the producers in running the required 10-hour test.

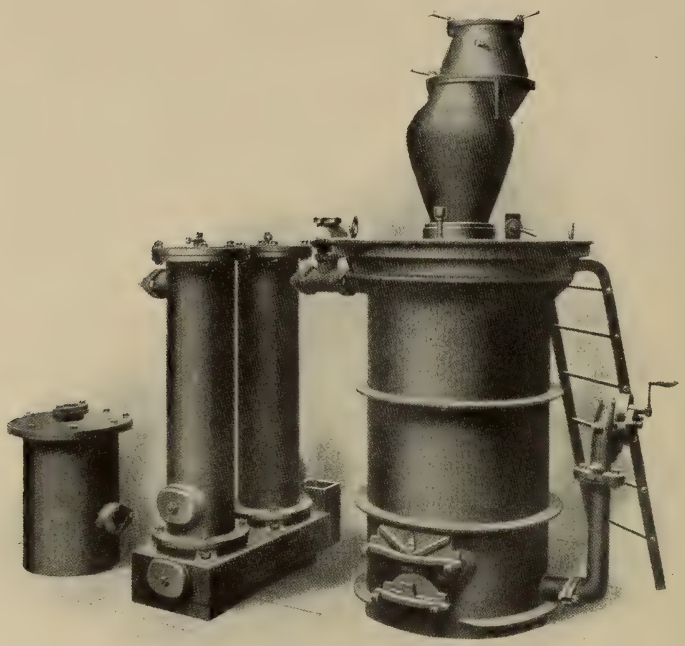


FIG. 11.—SUCTION GAS PLANT MADE BY MESSRS. CROSSLEY BROS., LTD., MANCHESTER, FOR USE WITH GAS ENGINES IN SIZES FROM 5 TO 300 B. H. P.

On the whole of the trials, of six large and four small producers, the average coal consumption per B. H. P.-hour was 1 pound, costing one-twentieth of a penny at the price above given—9s. 3d., which means that a 20-B. H. P. engine can be run for a cost of 1 penny per hour. This average of 1 pound of fuel seems to be capable of being, with reasonable safety, taken into calculation. In the small-size plants, the fuel consumption varied from a minimum of 0.87 pound to a maximum of 1.30 pounds. For the larger plants the average fuel per B. H. P.-hour for the full and half-power loads combined was practically identical, showing that some plants were more economical at full load while others gave their best results at half loads.

These figures are given merely as a general guide. The trials were of producers and engines combined, and cannot therefore be quoted as examples of producer tests alone. Thus the engines showed a mechanical efficiency as low as 61 per cent. for half-load of small engines up to 86 per cent. for full-load of larger engines. In order to test different producers correctly, the same engine should be used for all.

It may be asked how large the producer should be made for a given power. These test figures furnish this information, the capacity of the producers per declared B. H. P. being given. Presumably this capac-

ity is that of the fuel combustion space, and it appears to be usually about a quarter of a cubic foot, though one of the larger producers had a capacity less than half this figure; yet it is reported to have completed both trials without a stop.

In the smaller producers the capacity varied from 0.161 to 0.372, averaging 0.257 cubic foot, as against 0.230 cubic foot for the larger ones. In both sizes the extreme capacities have a ratio of over 2: 1.

Perhaps the general drift of the results is in favour of the larger capacities, but there is no really striking difference, and much error will not be made if a mean value be taken of 0.250 of a cubic foot per B. H. P. or, say, 450 cubic inches. In the case of a producer of only 0.161 cubic foot per declared B. H. P., it is true that the B. H. P. fell to little over three-fourths of its declared value, so that even this producer had over 0.210 cubic foot capacity per obtained B. H. P. The producers with the large capacity, on the other hand, exceed their rated B. H. P. In the one case the excess of power was nearly 22 per cent., and, so far as these figures may be taken as a guide, it may be said that from 0.2 to 0.3 cubic foot per B. H. P. are reasonable limits within which to work.

As a general guide to floor space required, it may be stated that for a certain make of producer a floor area of 7 feet 6 inches by 5 feet is sufficient for 15 to 25 B. H. P. An area of 12 feet by 8 feet 6 inches is needed for power of 78 to 95 B. H. P., and of 16 feet by 11 feet 6 inches for 211 to 250 B. H. P. Approximately the smaller size requires barely 2 square feet per B. H. P., and the larger size less than $\frac{3}{4}$ foot, an even

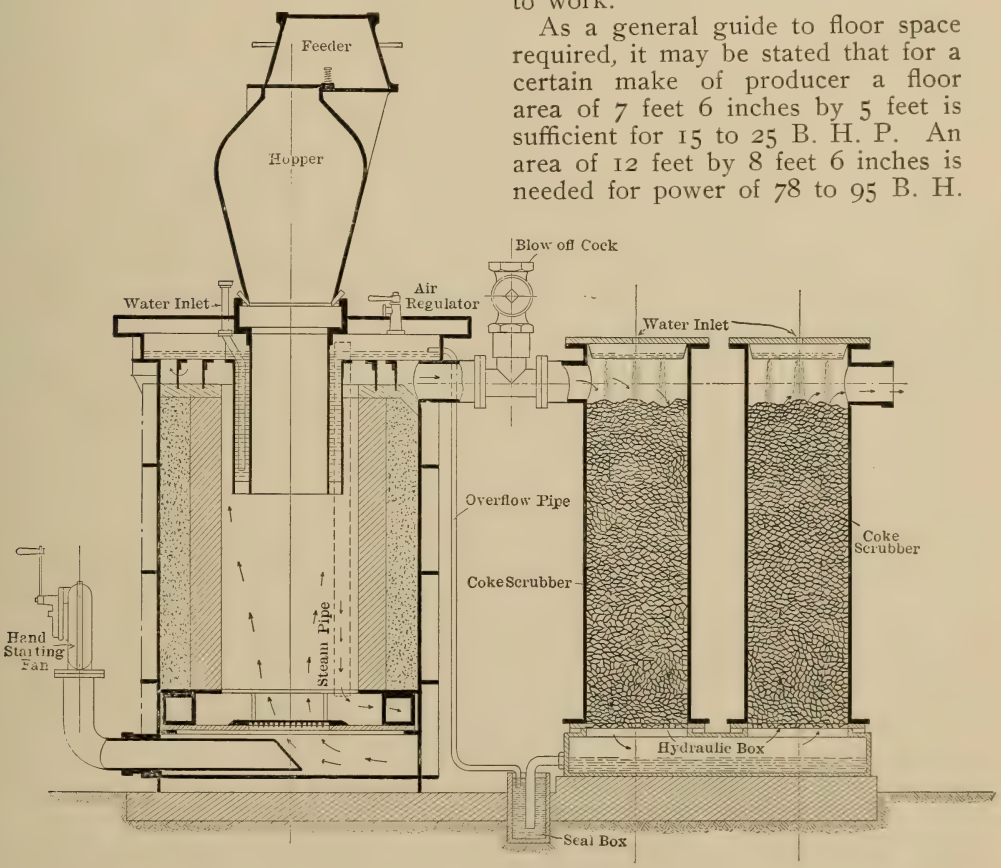


FIG. 12.—SECTIONAL VIEW OF THE CROSSLEY PRODUCER

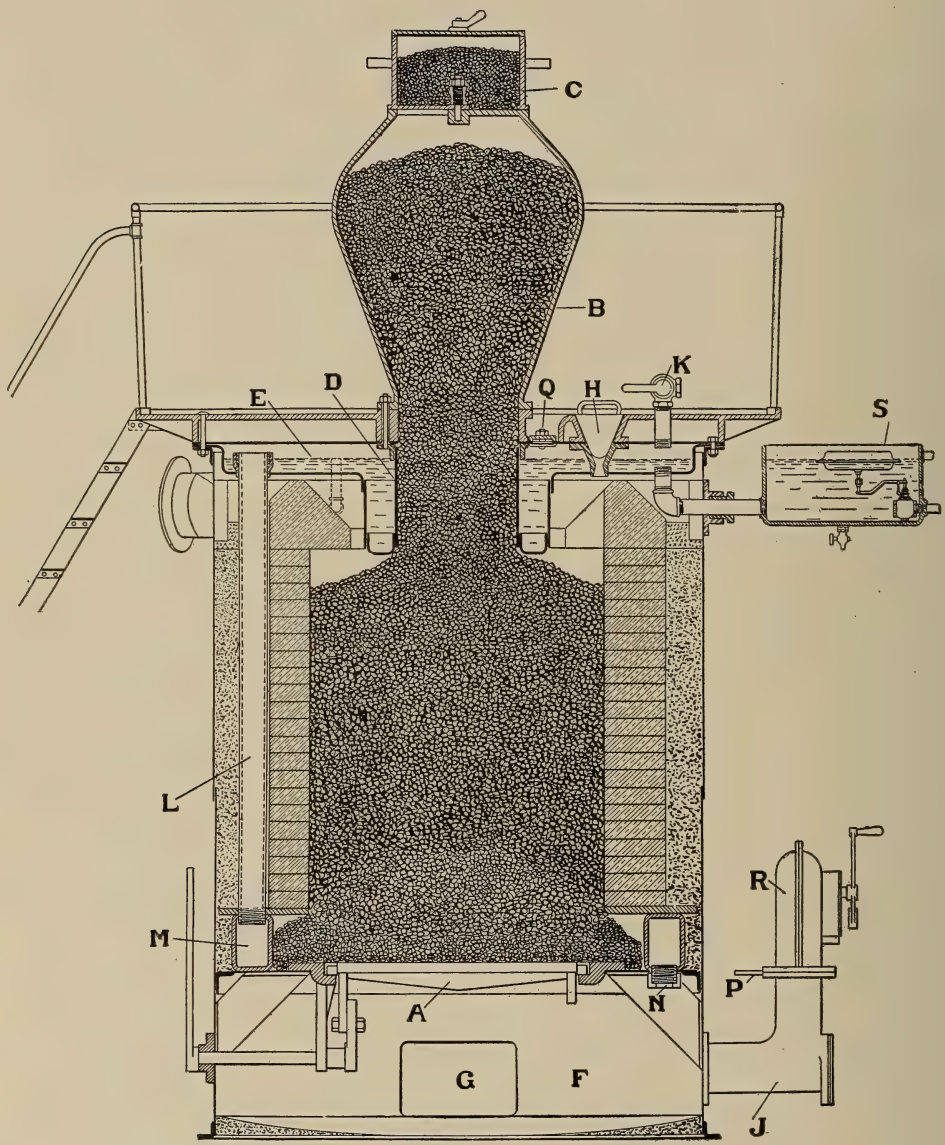


FIG 13.—THE AMERICAN CROSSLEY SUCTION PRODUCER, MADE BY THE POWER & MINING MACHINERY CO., NEW YORK

square foot being required at about 100 B. H. P.

This article would be incomplete without a reference to the analysis of the gas from producers. Table I. is given by Mathot as fairly representative of a few manufactured combustible gases.

TABLE I.—KIND OF GAS

	Blast Furnace.	Producer.	Mond.	Mixed Fichet.	Water Strache.	Wood Riché.
Oxygen and nitrogen	60	59	42	50	5	1
Carbon monoxide CO	24	25	11	20	40	29
Carbon dioxide CO_2	12	5	16	7	4	11
Hydrocarbon CH_4, etc.	2	2	2	3	1	15
Hydrogen	2	9	29	20	50	44
	100	100	100	100	100	100
Weight per cubic ft. lb.	0.08	0.07	0.06	0.068	0.042	0.051
B. T. U per cu. ft.	105	122	155	144	266	327

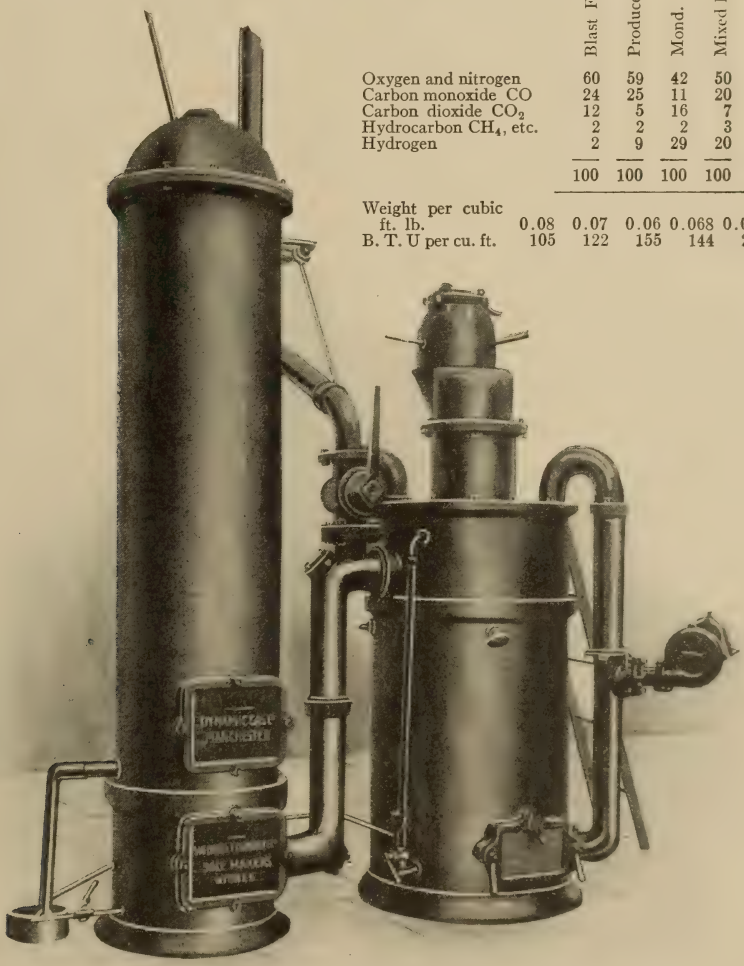


FIG. 14.—A SUCTION PRODUCER MADE BY THE DYNAMIC GAS COMPANY MANCHESTER

From these figures it will be observed that producer gas differs from blast-furnace gas chiefly in its smaller contents of CO_2 and its greater contents of hydrogen. The CO_2 in the blast-furnace gas is due probably in part to the driving-off of the gas from the carbonate of lime flux. The hydrogen comes from the moisture naturally present in the air blast. Mond gas owes both its high CO_2 and high hydrogen to the very great weight of steam blown through the generator, the temperature of which must be kept up by complete oxidation of a considerable weight of car-

FIG. 15.—A SUCTION PRODUCER OUTFIT MADE BY MESSRS. WHITFIELD, LTD., KETTERING, ENGLAND

bon. Water gas is produced so powerful as it is, simply by blowing the producer and running the CO_2 to waste.

Then, when hot, the producer is steamed and CO and H are formed which are diverted to the holder. The Riché gas is simply retort-made gas from wood.

As a comparison with illuminating gas, the adjoining analysis of the Manchester public supply is given:—

The calorific value of ordinary "town" gas is about 650 B. T. U. per cubic foot. The particular quality of blast furnace and producer gas is the smallness of their hydrogen. Blast-furnace gas is particularly low in this respect, and since it contains also a fair quantity of carbon dioxide, CO_2, it is not a very

MANCHESTER GAS ANALYSIS

	Per cent.
Hydrogen H	46
Carbon monoxide CO	7
Methane CH_4	35
Various hydrocarbons	6
Carbon dioxide CO	4
Nitrogen N	2
	100

explosive gas. It will endure a considerable compression without pre-ignition, and it is therefore a particularly suitable gas for large engines in which pre-ignition constitutes a serious danger. Producer gas is by no means rich in hydrogen, and should suction or other producers come to be employed for large engines, the hydrogen can be reduced should it be found necessary.

For manufacturing purposes where hot water is required, the waste heat of the producer can be very usefully applied, and there is then no economy to be gained from producing hydrogen. If gas producers are worked "dry," they give results therefore slightly different, a Thwaite producer with coke giving,—

Nitrogen	61.4
Carbon monoxide	27.8
" dioxide	3.4
Hydrogen	5.5
Marsh gas	1.9
	100.00

The thermal value of this is 128.6 B. T. U. per foot. Such a gas at the factory of A. Porritt, of Birstall, gave the following all-round economic results from each 100 of coke value:—

Used in gasification and radiation loss	10	
Heat returned by condenser	9	
" converted into work	18.5	Heat value of gas 81
" in engine jackets	44.5	
" in " exhaust	18	

Thus the engine converted into work 22.8 per cent. of the heat value in the gas, and there was available for water heating and for drying purposes 63.5 per cent. of the heat value of the fuel.

Suction producers may be worked equally well on the dry system, though unless the engines are large and there is no need for heat, it is as well to produce some hydrogen. Mr. Thwaite, however, for large engines, objects to more than 5 per cent. of this gas as interfering with

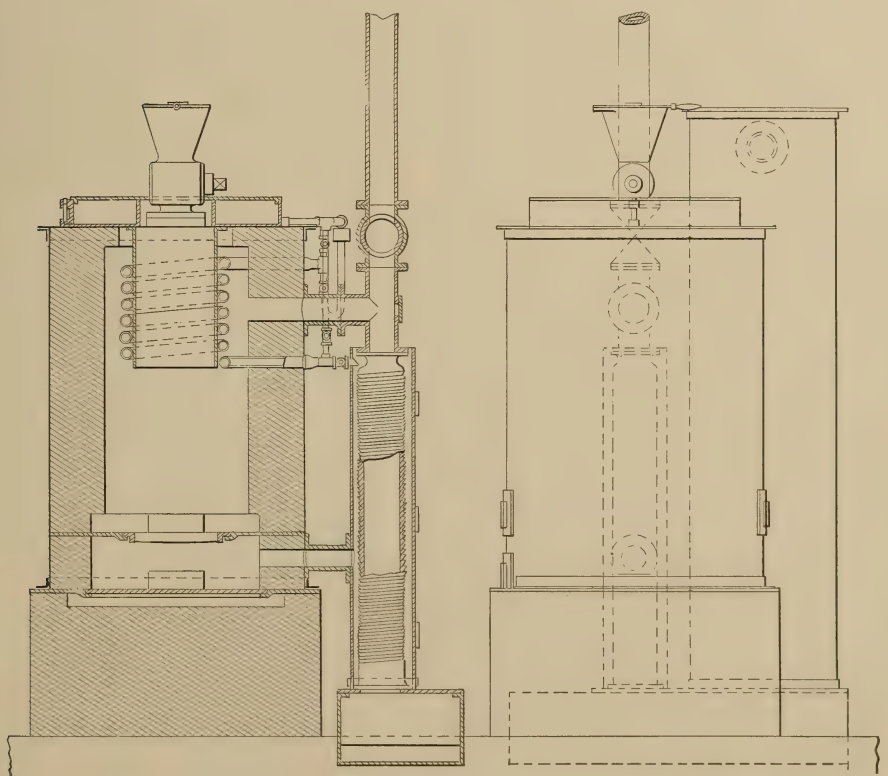


FIG. 16.—SECTION AND ELEVATION OF THE WHITFIELD SUCTION PRODUCER

high compression, for gases rich in hydrogen ignite more easily and at a lower temperature than purely carbon gas. The degree of compression must, therefore, be moderated and the advantages of high compression must be partially sacrificed.

Strong proof of this is given by the great success which has attended the use of blast-furnace gas in Germany. There the large gas engine is the direct outcome of the use of blast-furnace gas. Containing very little hydrogen and being of low calorific capacity, often considerably below 100 B. T. U. per cubic foot, this gas will stand a high compression without danger of pre-ignition and will give a slow burning which is necessary to the best results in a water-cooled cylinder.

Where a small engine may be run with a gas containing a considerable percentage of hydrogen, this cannot be done with equal impunity in the case of a large engine. In a case which came to the author's knowledge, the leakage of water into a blast furnace from a split tuyere caused dangerous pre-ignition and reversed a large engine to its imminent danger and great stress.

The suction producer of the Dynamic Gas Company, of Manchester, shown in Fig. 14, is made in sizes up to 130 B. H. P. It is claimed that the cost of running an 80 per cent. load, i. e., one of 80 per cent.

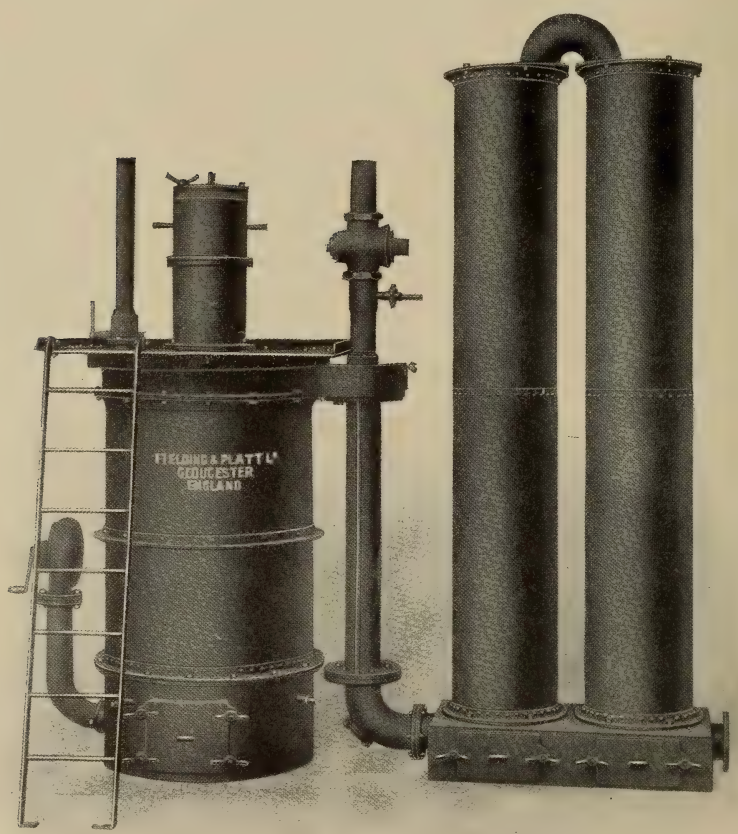


FIG. 17.—SUCTION PRODUCER OF MESSRS. FIELDING & PLATT, LTD., GLOUCESTER

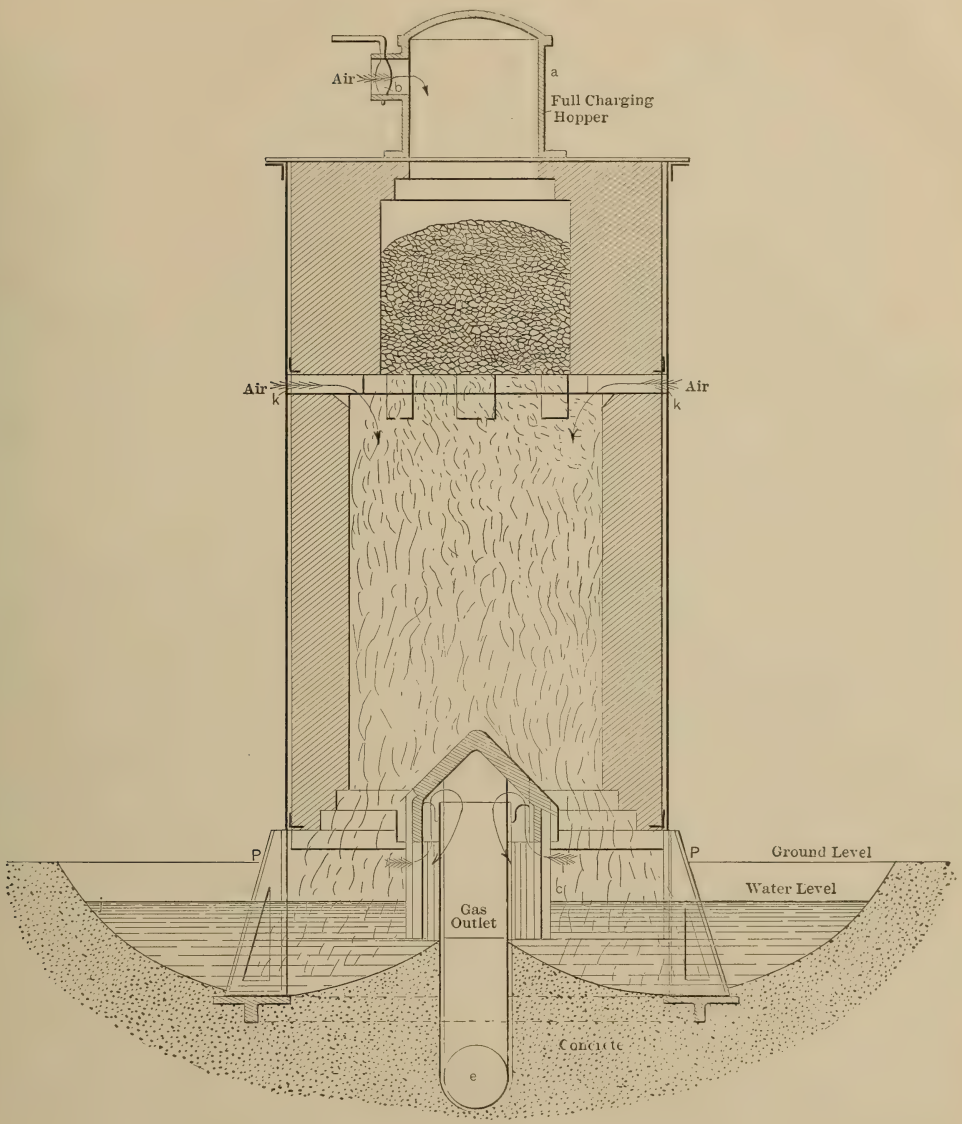


FIG. 18.—THWAITE'S PRODUCER

of the full power of the engine for 54 hours per week of a 50-week year will not exceed $\frac{1}{3}$d. per B. H. P.-hour with coal at 26s. per ton, oil, waste, rent, water taxes, and 10 per cent. for interest charges, etc. For fuel alone one-tenth of a penny per hour per B. H. P. will suffice.

For larger plants the cost falls, and for longer hours it of course falls also, so that for a plant of 110 to 130 B. H. P. the cost per B. H. P.-hour for a year of 7200 hours or continuous 80 per cent. load is set down at $\frac{1}{4}$d., or at 1·17d. for fuel only.

These statements about continuous runs show that there is no real occasion to stop the working of a producer. Its clinker and ash can always be removed while at work, and the plant as a whole is very sim-

FIG. 19.—SUCTION PRODUCER OF THE DOWSON ECONOMIC GAS & POWER CO., LTD., LONDON

ple. There is, of course, some trouble to be expected from hard water in the vapourizer, and soft water should be employed if possible, but a vapourizer can be cleaned and, after all, does not a steam boiler scale much more rapidly?

The following analysis of gas is from a "Dynamic" producer:—

	Per cent.	
Hydrogen H	17.00	
Oxygen O	0.19	
Methane CH_4	1.51	
Carbonic oxide CO	23.05	
Carbon dioxide CO	7.99	
Nitrogen N	50.26	
	100.00	
Total Combustible	45.5	per cent.
B. T. U. per cubic foot	153.7	

From the above analysis it is evident that the aim is to produce a fairly high percentage of hydrogen and some of the carbon is burned to dioxide for this purpose, that is to say, to produce the heat necessary for the splitting up of so much steam as is represented by the 17 per cent. of hydrogen.

In the suction producer made by Messrs. Whitfield, Ltd., of Kettering (Figs. 15 and 16), the gas from the generator is drawn through a vertical vessel exterior to the generator. This vessel is of cast iron, and on its outer surface there is turned from end to end a coarse screw thread, the upper face of the thread having a

downward slope to the body. Water admitted upon the upper part of this thread is thus compelled by gravity to descend over the whole surface of the thread and against the body of the pipe. The heat of the gas inside this saturator evaporates the descending water. Over this screw is an outer casing, open at each end to the atmosphere, and at the middle to the generator under the grate. Air enters at the ends of the casing and carries with it the steam produced upon the screw saturator. The pull of the engine is steadied and rendered less spasmodic by a water box and suitable regulating plates, and the working of the generator over a wide range is thus made possible. The proportion of water run over the screw is suited to the general conditions of work. It is claimed for this plant that dust is well separated out, and that when running light too much steam is not carried into the fire to produce a chilling effect. A means is provided for testing the gas while the producer is at work. The starting fan is fixed between the engine and the scrubber and draws gas through the whole plant, producing a pressure when required at the trial cock.

The similarity of all suction plants is shown by Fig. 17, which illustrates the producer of Messrs. Fielding & Platt, Ltd., the 60 B. H. P. plant occupying a space of 12 feet by 6 feet; but at the same time the various slight differences of various makes of producers are exemplified by this plant also, for, unlike the last described plant, the starting fan here blows air into the producer, whereas in the Whitfield plant, gas was drawn through the plant for starting as well as during working periods. Messrs. Fielding & Platt rate at 200 B. H. P. a suction plant measuring 12 feet 9 inches by 11 feet and weighing 6 tons approximately.

Thwaite's duplex inverted suction generator is shown by Fig. 18. The fuel is fed into the generator by the hopper *A*. A valvular opening *B* is provided in the hopper frame to permit the primary combustion air to enter; the fuel ignites, and by suction effect the gases produced by initial combusion are drawn downwards through the column of fuel, escaping through the vertical grille *C*, hanging from the cone-shaped casting *D*. The gas finally flows to the engine by means of the pipe *E*. The ashes and clinker gravitate to the base and into the hydraulic bath, from which they can be drawn by rakes inserted beneath the curtain seal plate *P* that dips below the water level *J*.

The secondary air supply enters the generator through the numerous ports *K*, distributed around the shell of the generator. This secondary air supply sets up a high state of incandescence at the level *L*. In passing through this level or zone the tar-carrying gases are not only fixed, but the dirty gas will be more or less scrubbed. Of course, this type of generator is only suitable for coals containing a comparatively small portion of volatile hydrocarbons. It is, obviously, available for all other fixed carbon fuels, such as coke or anthracite. A belt permits the secondary air openings to be closed or opened as desired.

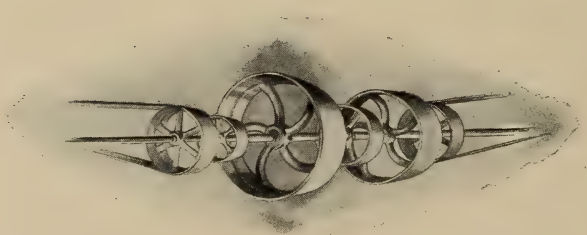
The Thwaite suction plant is equipped with an ingenious governor arrangement that maintains a continuous aspiration effect in the generator and permits the engine to draw its supply without such suction setting up a wire-drawing influence.

In conclusion, it may be remarked that there is really very little to say on suction producers, for they are but a variant from the ordinary pressure producer. They are the direct outcome of a demand for small and cheap plants and afford a quite natural solution of the question, why not make the engine draw its own gas supply as it does it own air supply? Obviously, a gas plant offers some resistance to the flow of gas, and the best producer is one that

maintains this resistance at a low, but steady, figure. Should the gas resistance vary, the mixture of air will vary, and there will be irregularity in working. It should be the aim of the maker to secure a constant resistance and to arrange the resistance of the air inlet to suit the resistance of the gas, so that each may be drawn into the cylinder at a steady rate in true proportion.

The object of suction gas design should be to reduce to a minimum the pulsating effects of the engine in order that while the engine shall always have a free supply of gas ready to enter its inlet ports, yet despite the spasmodic demands of the engine, the pull on the producer shall be comparatively steady. There should be no tendency of the suction to lift and disturb the fuel, whereby dust may be caused to travel forward with the gas. It must be remembered also that in a suction producer the tendency of the stream of air flowing through is to take the shortest line between entry and exit of any vessel, whereas in a pressure producer the stream becomes diffused. Care should therefore be exercised to so design parts as to prevent any short-circuiting tendency.

Then, again, too much should not be sacrificed to cheapness. It is true that the gas plant is under no pressure, but it is a mistake to make it of thin sheet metal. It should be of good, stout plate—a minimum of $\frac{1}{4}$ inch thick. With sound workmanship the cost of maintenance will be a minimum, and with good design there is no reason for that fluctuation in the quality of the gas that has been so much complained of. The suction producer is, in brief, in its best forms merely an adaptation of known chemical laws to fill a special demand. It will be able to put up a hard fight against electrically distributed small amounts of power.



POWER HOUSE ECONOMIES

THE IMPORTANCE OF DETAILS OF OPERATION

By W. P. Hancock, Superintendent of the Generating Department of the Edison Illuminating Company at Boston

ARE you looking closely after some of the very important items of power house operation which, generally speaking, are not discussed very much in detail? For instance, consider the matter of fuel.

That item may reasonably be 50 per cent. of the total generating cost, dependent on the distance you are away from the mines whose product you consume, the base price, transportation, insurance, handling, the type of apparatus with which you make steam, the class of labour you employ in your boiler room, and the type of apparatus that consumes the steam. The fuel item may be even a much larger percentage of the total.

Lay aside, for the moment, the question of the type of apparatus in use in the power house, and consider whether or not you are having your coal shipped to the best advantage to your company, after taking into the question the point or points at which shipment is made, the location of your power house, your facility for storage and handling, and the possibility of strikes or other delays of delivery.

Are you provided with coal handling apparatus which will enable you to unload the fuel quickly and at low cost, and also such handling apparatus as will enable you to handle over from 10,000 to 75,000 tons of fuel, in case there is a tendency toward heating? You need such an apparatus if you store coal for purposes of emergency, for the only true way to subdue the accumulated heat in stored-up coal is to handle the coal, open it up to the atmosphere, and save all the gases possible until the fuel reaches the furnaces, and have them consumed, so far as you are able, under the boilers, instead of letting them waste in the open air.

The writer knows, from actual observation made with good bituminous coal, and covering a period of two years, that there was a loss of 6 per cent. in the heat value of the coal as burned, after it had been in open air for the above length of time, and had heated more or less also. Some analyses of weathered coal may show a smaller loss, but if you want to take the trouble of keeping a daily record of the coal consumed per KW.-hour of output, as I do, and have a large amount of coal in the open air, you will find that the figure mentioned represents a fair average. I, therefore, say that a "hot coal

pile" should receive immediate attention, not only to save the difficulties of fire, but also for the purpose of retaining for your benefit the substance of the coal.

If your fuel is coming to the furnaces in as good condition as is possible, after all points have been considered, then the next thing demanding attention is its consumption. Twenty years ago most electric light stations had dead grates and the ordinary furnace, hand-fired. To-day we have the best type of hand-fired grates, among which are some of the "shaking" type, others of the "water" type, and as against these we have also several types of mechanical stokers.

Of course, you know, or ought to, that to-day it is perfectly possible with a mechanical stoker to burn coal in the power house for 40 per cent. less money than is possible with the best hand-fired grates. I mean by that that a mechanical stoker which is suitable for the grade of fuel burned will show such a result if properly operated, and the reduction will show after considering the cost of labour, repairs, and every expense incurred in the fire-room. Are you taking advantage of the opportunity to install and operate this form of mechanical apparatus, and are you receiving the proper benefits from it?

Do you realize that it pays, when you have installed a piece of apparatus, which is a work of art in its line, to hire, for its operation, a class of labour with good mechanical ideas, men of a different intelligence from that of the average fireman found in the average fire room?

Don't give the same old time-worn answer, that you "cannot get them, and if you could, they would be too expensive for your business," for if you do, I will reply that you cannot afford to operate without them.

You can get them, and when you have had them on your pay-roll long enough to be sure they are the right men, treat them in a way that will make them want to stay with you as long as you need them. Make them contented by paying a wage that is fair; give them good facilities for dressing and keeping clean; prove to them beyond reasonable doubt that you have their interests in mind to a proper degree.

On the other hand, require from such men the best effort they can put forth, in return for such remuneration as I have mentioned,—demand it, if necessary; you will get all you can reasonably expect, and without discontent, grumbling, or loss of discipline. This is not theory on my part, but deduction from an experience with the handling of men in power house work which has covered quite a period of years.

When we have got the coal inside the furnaces, we begin to understand what it contains, in substance, that is valuable for steam purposes, and we also find that it does not follow that everything in the coal pile is fuel. Without talking of analysis of the fuel, we will assume that it contains from 10,000 to 15,000 B. T. U., dependent on the location of the mines, and speak of the ashes.

Have you purchased the fuel on the basis of the several analyses submitted by the coal dealer, and if so, have you burned one or two hundred tons of the coal, and carefully noted the percentage of ash? How did the printed statement agree with the fact?

You certainly want clean fuel. You cannot afford to pay for an abnormal amount of refuse in coal, coal that contains an unwarrantable amount of slate, broken stone, and fine slack so-called, which turns out in some instances to be nothing more or less than the surface portion of a coal storage field coloured black. Just what does that mean?

You have a base price on the fuel, and you are, in the first instance, paying that price per ton for the materials mentioned above, and think of the pounds per KW. consumed. You are also paying freight, insur-

ance, and cost of handling on the same stuff.

You are paying for labour to put something through your furnaces that gives a return of the wrong kind,—a cost for repairs,—besides extra labour on cleaning fires, another extra cost for abnormal amounts of ash, and its removal, unless you are fortunate enough to sell your ashes.

And if you can sell your ashes, we are not all able to do so, and, further, it costs at some power houses that I know of 23 cents per ton to haul them away. The ashes in the coal may average 5 per cent., which is fairly low, and the average for a while, on the same grade of coal, may be 10 per cent., and perhaps 11 per cent., which is very high; but it is not so low in the one case or so high in the other but what the writer has had plenty of experience in both lines, and can realize fully the importance of watching carefully the residue from the furnaces.

Have you a laboratory in your organization? I ask this question because you should analyze your coal by sample as it comes to you, and find at least the heat value and the percentage of ash that it contains.

In short, there is only one true way for the consumer to buy coal, and that is on the heat value basis. Say to the dealer we will pay you a stated price for your coal, provided it contains a stated value in heat units per pound of dry coal when unloaded at the power house, or on such premises as you may designate, the values to be determined by analysis. For anything less than the stated heat value per pound a pro rata reduction in price shall be made to the purchaser, or the purchaser may reject it altogether. For any additional heat value, over and above the stated value, a pro rata addition shall be made to the price per ton for the vendor.

Such an arrangement would prevent a coal concern from clearing up a coal storage field when conditions best known to themselves made it seem proper, and continue with the grab bucket and shovels to clean it as long as anything black remained, making the purchaser pay for tons of dirt, which, when passed down the chutes to the fires, would practically bank them, for you could not ignite some of it if it fell on a clean six-inch fire, operating with 0.6-inch draught in the back connection.

Take the other side. If the vendor sends you a grade of coal better than he thought he could procure at the time the agreement was made, he gets his additional compensation by the terms of that same agreement. What we need most is some sort of positive assurance that if we pay for 15,000 B. T. U. per pound of coal we shall receive that kind of coal, and it seems to me that what I have outlined as to agreement between vendor and purchaser is the way to gain such assurance.

I do not claim to stand in the position of suggesting an idea that is new, for I understand that some companies have already adopted this method of buying fuel; but I do wish to be understood as favouring the method, because it is fair, and because one can estimate much nearer what his expense for fuel will be if he takes into consideration at the same time the boiler and heat efficiencies of the system.

If we could have such a method, we could not only save a lot of tiresome argument with the coal man, but we should register a positive saving also, by knowing that we should need a certain amount of boiler H. P. in service for a certain load, and we should not have to figure on keeping in one or more extra boilers simply to provide for a coming load with a bad run of coal.

How about the repairs in the boiler room?

Are you keeping them up just where they ought to be kept?

Have you acquired the habit of saying,—"We cannot afford to fix that matter up now,—not until next

month"? Perhaps it comes to your mind that way at times, and if so, what is the result?

On that principle, one steam leak gains company until you have half a dozen, and then you say that repairs must be made. You get at them with a gang of men and do the work at a higher cost than if you had pulled up the joint when the first leak appepared, or replaced a gasket, as the case might be, with a couple of men who are working on the fixed payroll. If you do a lot of them at once, you either neglect some of the work which every day brings forth, or you hire extra men and raise your labour cost per KW.-hour.

But the matter does not stop there. You had the leaks, steam and heat were getting away and not giving you the return for the money you paid for the coal. You trespass on the coal pile whenever you allow such things to occur. Therefore, don't let the leaks accumulate, nor forget that a "stern chase is always a long one." Don't slowly, but surely, sink money out of sight by labouring under the delusion that you cannot afford to make repairs when they first seem necessary, or rather when the difficulty first appears. If you do, more dire results will come than those spoken of; for a little later on the man "higher up" wants to know "why the steam end of the system is not more efficient."

Let us hope that at that particular time you have learned the folly of neglect, and know that he refers to a previous month, before repairs had been made. If he has made that inquiry, and you are still behind on repairs and unable to give satisfactory answer, what is the probable result? Manager quietly brings some person into the system who looks it over and suggests things. Suggestions are accepted, system is straightened out, and the improvement in the next few months astonishes and pleases.

But the manager still is thoughtful; he says nothing new has been installed, load is about the same. Why is it? Makes more inquiries of his expert. Gets the truth. Then the realization comes that operating of that type will not provide such returns on investment as stockholders have a right to expect. What next? Some men are abrupt, and won't stand foolishness, especially if it costs money. Can you blame them?

There are small supplies to be purchased and consumed. Are such supplies being used economically? For instance, oil and waste are a good line to keep your eye on. Do you use grades of these goods which meet your condition as nearly perfectly as possible?,

Does your cylinder oil cost too much or too little? It is perfectly possible that either one of these conditions may exist.

And as we are speaking of oil, it is well not to lose sight of the fact that there are more things than the first cost of oil which can make the total cost of the lubrication of the system economical or otherwise.

If you are a buyer of oil you have probably considered the size of the units, the piston speed, the type of valves you operate, and the temperature of the steam at the throttle; and you have used the facts to help in securing an oil that will fit your conditions best.

Undoubtedly you have had calls from several salesmen who wished to do business with you, and perhaps each one of them was confident that he could save money for you in spite of any other proposition that had been made to you; and no doubt you have tried one or more different grades of oil.

Perhaps in two or three instances the grades were alike, but the names were different on the bills and packages. What has been the result with you? Are you using a very cheap cylinder oil, so cheap, in fact, that you must send through to the inner parts of the unit an abnormal quantity?

Does the quantity you are con-

suming amount in money to just as much as a smaller quantity of a better grade would? Could you not use the better grade, and at some advance in cost, and save on labour, save anxiety, and get better results with the wearing surfaces? If you are using the lower grade you are getting an oil that, per gallon, may be cheap in price, but you may be quite sure that you are not getting the proper economy, and therefore you are using an oil that is costing too "little" per gallon.

Perhaps you are using an oil that is shipped to you under a name that has been mentioned to you as the "only thing" to use. The price of this article looks as high as the price of the other goods, which were not satisfactory, looked low, but as you are told you can "save money," and because you have also been told that it will fit all of your conditions, you adopt it for a time.

You awake to the fact suddenly that you are still in the "deep woods," for while you are, or may be, getting the best in the market, you realize that your cost for cylinder oil per unit of output is still too great, and is not appreciably changed from the cost shown when you were using the cheap grade. If such conditions as these are found, then you are using an oil that is costing too much.

At this point there is one thing especially that you must do, and that is, stop letting people who are on your premises only at such times as they come to sell goods tell you what you ought to use. Take no person's word; go at it yourself and dig out the truth; get some goods that you think, after going over your experience, may fit.

Try them on your units, analyze them. If you have not a laboratory outfit on the system, engage a chemist to do the work for you; have the base or the composition changed until it fits your conditions as perfectly as possible, and to define that, I mean change until your lubrication is perfect and costs you less than ever before, and when you arrive at that point keep on trying to make the cost still less by other methods, of which I will speak.

If, then, you have got an oil that suits, the next thing to look after is its economical use. How do you handle your oil, generally speaking? Have you a good filter system? Have you good mechanically operated positive feed cups in operation? Have you a man who takes care of the oil, and who is held as responsible in his particular position as a watch engineer is in his?

You need all of these accessories, and if you have not in use all I have mentioned, but still claim you do not need to incur such expense, then I say you do not know the facts as well as those who have tried both old and expensive methods, of not paying much attention to lubrication, and the best way of giving it all the attention it needs.

Your man in charge of oil should receipt for all the goods and know whether or not the company gets what it pays for. He should have the oil pumped into the system, and know how much goes in; he should also be able to say what oil he has on hand in the filters, and out of them, at the end of every month.

He should have the empty packages returned promptly, so that the credits will come along regularly, and not all at one time, and thereby distort your cost figures of one month in comparison with another. He should especially report any seeming abnormal consumption of oil, so that steps may be taken to detect leakage in the oil system. He should watch the quantity of waste, or wipers, used, and see that the material is not misused.

You need that kind of a man, and you can afford to pay him for the saving he will make for you. I will say at this point that I can save 10 per cent. by using wipers, instead of picked waste, and they are more satisfactory. When the oil gets through

the piping to the engine room, then comes the trial of patience, in order to get oilers to understand that oil costs money, and that their duty is to see how little oil they can put through and have the requisite lubrication for the unit.

There are oilers and men who say they are oilers. The men who are oilers are not the kind that set the feed on the cylinder cups so that they know sufficient will go through to assure lubrication without reference to the actual amount that is passing, and who continue to fill the cups with a frequency and regularity that will give you a bad half hour when you see the oil account at the end of the month.

Plenty of oilers are to be had at a reasonable price,—men who will obey instructions as to lubrication, and take an interest in the company's affairs in that line, and you need that kind. You will have to pay that kind good wages, but you can afford to and ought to. If you have got the type first mentioned and don't know it, don't blame anyone but yourself. You know the remedy.

By the way, how do the engineers and switchboard men co-operate? In other words, how are the units being loaded? Are you getting such a low load on some units that the consumption of steam and oil is wasteful?

Can you not step inside at times and try to see how the load could be better divided, so that you could operate to a better advantage as to economy?

I am offering these questions in the line of suggestion because benefits can, and have, come within the limit of my experience from operating along these lines. It is possible to effect very appreciable savings in operating by following such small details as those here mentioned, and if you have not tried it, don't take my word, but satisfy yourself on the point by proving or disproving my ideas, as herein presented.

I will say that the cost of oil and waste (or rather wipers) on the system which I operate has for the calendar year 1905 been $0.00008 per KW.-hour of output, and whether that is a higher or lower cost than other systems can show, it is certainly lower, and much more so, than it was on the same system a few years ago, and the difference has been due to the close watching of the details.

I have hopes that I shall hear from others with reference to these and kindred matters of operation, and trust that such matters may appear in the columns of this journal for the benefit of people who have to do with operation of power houses, for in almost every system of generating, in different cities, different conditions are encountered, and the experience of all concerned is bound to be of value in some particular, and consequently of benefit in general.

THE ELECTRIC CITY OF THE FUTURE

By S. Morgan Bushnell

TWENTY years ago it was a simple matter for an electrical salesman to familiarize himself with his wares. The standard incandescent dynamo was built in a very few sizes, and each size was built for only one speed. A few hours of careful study and he could have memorized the prices, speeds, and general data of every machine on his list. To-day the salesmen of the great electric companies have several thousand different types of apparatus in their price books, and they are supposed to be more or less familiar with the entire line of manufacture. Not only has the manufacture of apparatus become much more diversified, but the needs and scope of the central lighting stations have become widely extended.

The first Edison central stations were installed for the purpose of distributing electricity for incandescent electric lighting. At that time no one thought of using arc lights on the same wiring, and while it was expected that there might be an occasional fan, power was considered an extremely subsidiary portion of the business and hardly worth considering. In the early days the companies sold current for power on the basis of the maximum horse-power as determined by ammeter readings, and the charge per horse-power was governed by consideration of whether the use of the power was continuous or intermittent. To-day electricity for light, heat, and power is sold almost entirely on a kilowatt-hour basis, as shown by mechanical watt meters.

When the direct-connected electric elevator was first introduced, the central station companies were opposed to it on account of the supposed undesirable character of the load. The great fluctuation of the amount of current required in electric elevators caused a great deal of trouble with the maintaining of even pressure for lighting, and various restrictions were imposed on the elevator companies with regard to the placing of direct-connected electric elevators on the lines. Central station companies preferred the use of electric pumps for hydraulic elevators on account of the fact that these would give a much steadier load on the motors. Now the situation is reversed; large elevator companies often find the central station companies actually going out and making a market for their electric elevators, sometimes almost against the will of the elevator companies. To-day the most progressive central station companies advise against the use of electric pumps for hydraulic elevators, and advocate, in the majority of cases, the use of the direct-connected electric elevator.

But there are other directions in which central station companies have extended their lines. A large amount of current is now used annually for various forms of heating apparatus. Many tailor shops are supplied with electric heating irons; electric soldering outfits have been largely used; and electric cooking in the ordinary household is becoming more and more frequent. A few years ago the central station was considered as a means simply of supplying power and light for small stores, for private

residences, and for small shops using only a very limited amount of power and light. The companies are now waking up to their opportunities, making attractive propositions and securing the business of some of the largest buildings and factories.

Twenty years ago the largest generator produced was the 100-KW. dynamo, which was belted to a 150-H. P. engine. For the Edison three-wire system, two machines would be belted to a 300-H. P. engine. To-day dynamos are being built with a maximum capacity of 12,000 kilowatts, or more than a hundred times the capacity of the largest machine built twenty years ago. These large generating units, which are now being installed, will produce power at about four times the efficiency of the smaller units of that earlier period.

The question that naturally arises, therefore, is,—"Has this development reached its limit, or have we merely reached a gateway leading to vaster and grander possibilities beyond?" If we should judge the future by the past, who shall say that we may not within the next twenty years have units of 100,000-H. P. capacity or even larger? When that time comes the present large factory or office building using 500 to 1000 H. P. will be as comparatively diminutive in its requirements as the 10-H. P. customer was formerly in connection with the old central station.

At the same time, new economies will be introduced into the distribution of power, and the result will be an inevitable cheapening of the cost of electricity. This cheapening will greatly accelerate the tendency which now exists among all classes of buildings to secure their current from the central station source of supply, and it would not be astonishing if within twenty years we should find architects paying as little consideration to the installation in their buildings of electric light and power plants as they do to-day to the installation of plants for the production of illuminating gas.

This result will, in turn, react on the central station and enable it to produce power in much vaster quantities than ever before, and the result will be an aggregation of power for a large city in two or three great electric power houses, in which all the elements entering into the production of electricity will be secured at a minimum of cost. This will react again on the lowering of the price of electricity, so that the use of electricity for lighting, for elevator service, and for the ordinary uses of power which we find to-day will be greatly increased, and mechanical power will drive out manual labour to a greater extent than has hitherto been known.

This reduced cost of current will greatly accelerate the movement which is now in progress in favour of diffused and concealed lighting. High-class apartments and residences, instead of being lighted by lamps placed in the centres of the rooms, in order to obtain the greatest amount of light possible, will be lighted largely by cove lighting and concealed lighting, securing a mellow effect entirely different from the glaring results which are now so common. Shades will be introduced which will form just the right combination of red, blue, and yellow rays, so as to avoid, on the one hand, the pale glare of the modern Welsbach, and at the same time avoid an excess of the red rays which have been found irritating to the eye.

The reduced cost of power will probably revolutionize also the present methods of refrigeration. Already miniature electric refrigerating plants have been designed, whose operation is absolutely automatic. These plants have thus far been successfully installed in a number of places, and the reduced cost of power will cause their adoption to a great extent, not only by the larger consumers, as at present, but also in private residences and apartments.

The push-button elevator is already found frequently in the more

elaborate residences. The reduced cost of power will not only stimulate the use of these elevators, but will tend to the adoption of escalators or moving stairways, so arranged that it will simply be necessary to turn a switch at the bottom of the stairs in order to ascend to the top. Automatic arrangements can be provided so that when the person leaves the stairway the current will be instantly cut off.

Apartment buildings of the future will have every possible contrivance for increasing the ease and comfort of their tenants. The old bugbear of "washing and wiping dishes" will be entirely removed, for each apartment will be provided with an electric dish-washing machine, which, with the aid of the hot water faucet, will automatically perform the operation. The future apartment building will be supplied with a carefully worked-out system of ventilation and will be constantly supplied with pure air, filtered and washed by modern and improved methods. The serving of meals will be largely simplified by elaborate systems or dumb waiters and signaling devices, so that the guest in an apartment building or hotel can have almost any dish served automatically without unnecessary delay by simply pressing a given button. Already in Berlin, Paris, and New York there are automatic lunch counters where customers can secure hot or cold dishes and hot or cold drinks by depositing coins in an automatic device which serves the various articles. There are no waiters to tip, nor is the customer annoyed by their awkwardness. All is done automatically by means of electric motors.

The reduced cost of power will be felt in every line of industry, and all lines of manufacture depending upon machinery for their product will be in a position to make lower prices on their goods. The old problem of three meals a day will be largely simplified by the use of electric sauce pans and other devices, which can be maintained at varying temperatures by throwing a switch in different positions.

The reduced cost of electricity will also have a marked effect on the exterior appearance of large cities. Myriads of lights, blazing along the most prominent thoroughfares, will turn night into day, and the standard of street lighting, which is already several times in advance of what it was twenty years ago, will be correspondingly advanced.

To-day thousands of tons of cinders and coal dust are annually poured out from city chimneys and distributed over buildings and thoroughfares, requiring the constant effort of a large force of men for their removal. This task will be much simplified by the abolition of hundreds of miniature power plants and the concentration of power production in two or three great stations where the combustion of coal will be accomplished on an enormous scale and so perfectly as to eliminate all smoke.

Not only will light and power for isolated buildings be furnished by electric current from the main central source of supply, but great systems of transportation, such as are required in a modern metropolis, will be supplied with the necessary power from the same generators.

RECENT BRITISH LOCOMOTIVE ENGINEERING

PREVALENT CHARACTERISTICS OF ITS DEVELOPMENT

By Charles Rous-Marten

IN reviewing the most recent developments which have taken place in British locomotive engineering it is essential that the various phases of the subject should be kept distinctly apart in the mind, and that the various aspects in relation to the main subject should be clearly appreciated and definitely differentiated; else much confusion of thought is inevitable and the true inwardness of British locomotive development must fail to be duly appreciated.

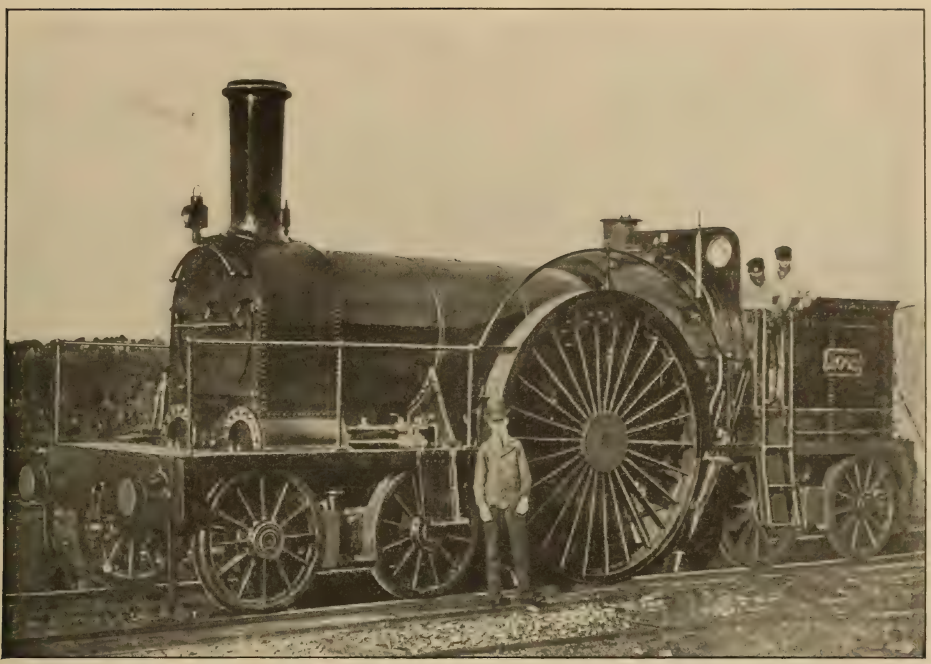
That the prevalent characteristic of these developments has been increased power is easily predicated, and also is quite true, so far as it goes. But the real interest and importance of the subject begin where this casual mode of generalization leaves off. Again, it is perfectly true,—and also utterly trite,—to say that the increment of power has been sought mainly in augmentation of boiler capacity.

It is obviously desirable to start with a clear perception of the points in issue, and I suggest therefore that we discriminate between the two senses in which the words "power" and "force" are commonly and often indiscriminately used. It will be convenient to consider "power" as that capacity for energy which may be wholly latent, or which may be employed to the utmost, and "force" as that power in action. There may be power without force, but there cannot be force without power. Let us therefore use the words in these senses.

Now, in a steam locomotive there exists in the boiler and fire-box, or rather in the water of the one and in the fuel of the other,—with the atmospheric oxygen as an indispensable ally,—the entire power of the machine, a power which can become active force exerted in a wrong direction if it should explode the boiler, or which can become tractive force if guided into its proper channels, i. e., into the cylinders, and employed there in pushing the pistons which turn the wheels that, by rolling in contact with the rails, cause the engine to move. All this is, of course, utterly rudimentary, but still it is not surplusage because it leads to the next step,—the allocation of a locomotive's functions to the different factors of its aggregate. Thus the question of a locomotive's power has to be considered under three distinct heads:—Production, transmission, operation.

Even these are redivisible, for the machinery of power production comprises the fuel; the fire-box in which that fuel is burned; the grate through which the supply of oxygen is furnished; the oxygen itself by which the needful combustion of fuel is supported; the water from which steam is raised; and the boiler in which that water is confined and in which the necessary ebullition for steam raising takes place.

Similarly, the machinery of power



A BRISTOL & EXETER TANK ENGINE OF THE YEAR 1855. DRIVING WHEELS, 9 FEET. CYLINDERS, 16½" X 24"

transmission has its different component parts,—the steam in the cylinders, and the cylinders in which it acts; the piston on which it acts, and the piston rod and connecting rod through which successively the force exercised by the steam is passed on to the operative machinery, which in its turn consists of the wheels which are turned, the cranks by which the connecting rod turns them, the rails through adhesion with which the resultant force is exercised, and the coupling rods by which the same force is conveyed to one, two or more additional pairs of wheels.

Accepting then these three divisions of the force-producing machinery as a convenient, if rough, classification, viz.,—(1) Production; (2) Transmission; (3) Operation, it becomes easy to trace the nature of the development and to make the needful comparisons of its various stages.

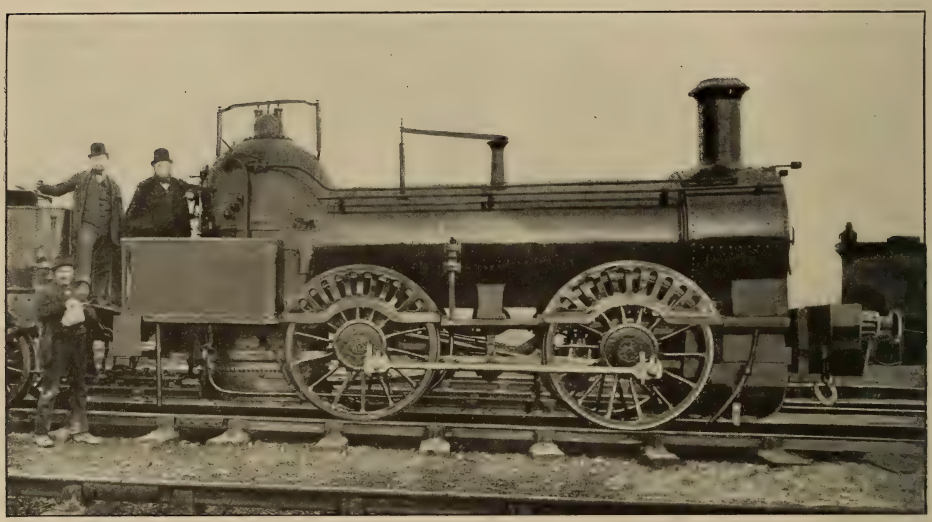
Prior to the opening of the past decade, and indeed in some cases almost up to the close of the nineteenth century, the process of development in locomotive power was confined almost exclusively to the machinery of transmission,—practically to the cylinders. Thus while the boiler power, estimated on the basis of heating surface and steam pressure, was, in some cases at any rate, as large in the decade 1845-1855 as in 1885-1895, or even in 1890-1900 as regards many cases; and while the prevalent size of the driving wheels remained practically the same in each of these periods, viz., 5 feet 6 inches to 7 feet for passenger engines, and 5 feet for goods, the cylinder dimensions increased from a usual size of 15 by 20 inches, or 15 by 22 inches, about 1846, to 19 by 26 inches, 19½ by 26 inches, 20 by 26 inches, and even 19½ by 28 inches in 1896. Yet by 1850-1853, the boiler heating surface had reached 1400 square feet, whereas, in 1890-1895 it rarely exceeded 1200 square feet, and in a vast number of locomotives was below 1100 feet. In many instances, including those of almost all the newest coupled engines of the Great North-

ern and South Eastern engines, it was actually less than 1000 square feet.

It is true that mere area of heating surface is not an adequate criterion upon which to base comparison of boiler power; for the relatively large heating surface of some well known engines built about 1850, for example the London & North Western Railway "Bloomers," by no means represented proportionate superiority as regarded steam generative efficiency over the much smaller heating surface of the "Problems" which came out on the same railway only a few years later and shared identical work for a number of years.

Nor could the 2290 square feet possessed by the eight-wheeled single-wheeler "Liverpool," belonging to the same railway and shown in the great exhibition of 1851, be taken as implying double the boiler power of, say, Mr. Johnson's Midland express engines of the "2600" class, or of Mr. Ivatt's "400" class of the same date, albeit the actual area was virtually twice as great.

Indeed, each of the boilers of the more modern locomotives just mentioned would probably put forth considerably greater power than that of the elder engine which had approximately double their heating surface. Still, the main fact remains that comparatively there was but little advance in respect of the nominal boiler power possessed by British locomotives during the forty years from 1855 to 1895.



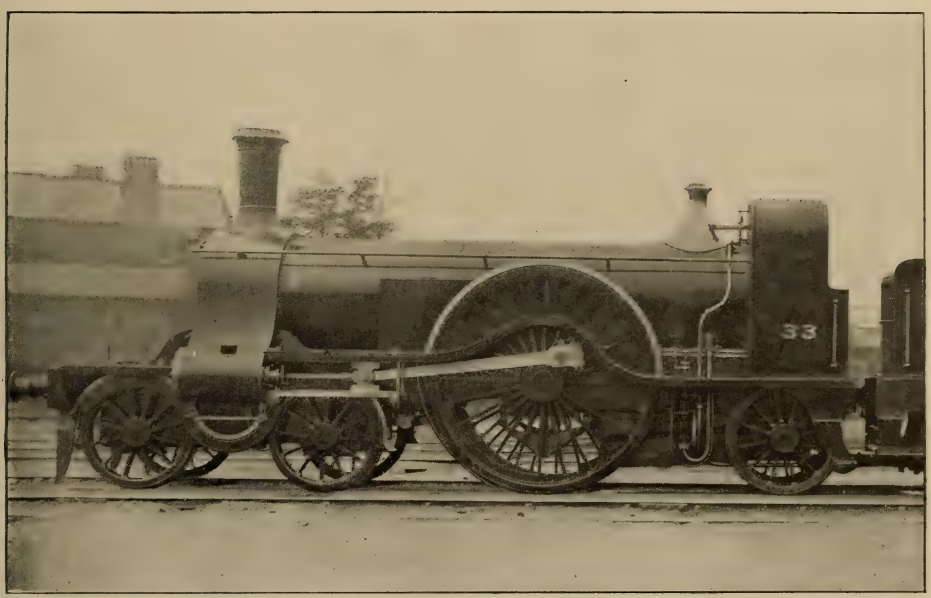
A LANCASHIRE & YORKSHIRE GOODS ENGINE OF THE PERIOD 1840–1850. DIMENSIONS UNKNOWN

On the other hand, the machinery of power transmission had steadily developed during those four decades. The Great Western in 1855, being then of 7-foot gauge, was therefore abnormal, and this abnormality was extended to the cylinders which, alone among existing railways, save in one experimental instance, were of 18-inch diameter in the standard passenger locomotives. No other leading railway in 1855 had even 17-inch cylinders, excepting again in two sporadic experimental cases on the Great Northern and the London & North Western, respectively. On the London & South Western, the London, Brighton & South Coast, the South Eastern, the Great Eastern, and the Midland, the largest cylinders were only 15 inches in diameter. The Great Northern and the London & North Western

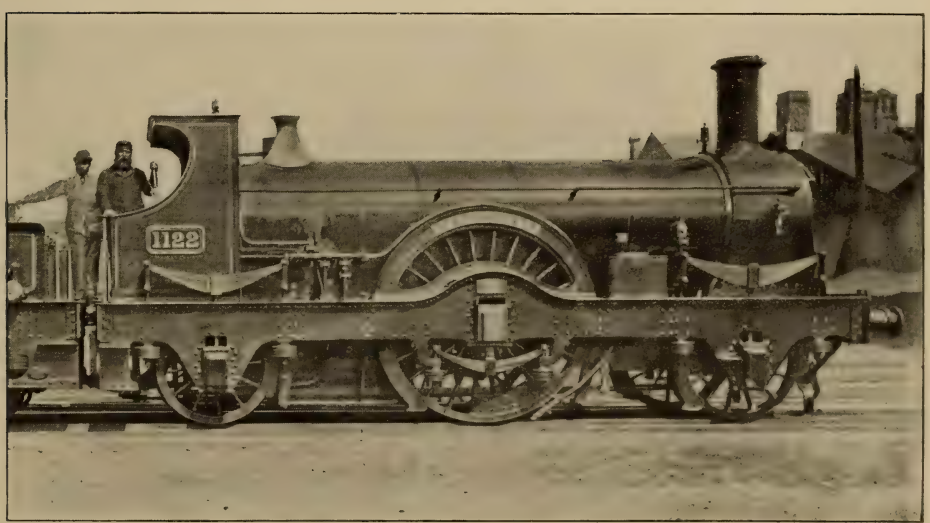
(Southern division) had a few 16 inches in diameter, but this latter size did not become at all general until the end of the fifties.

Then, however, came the steady onward march of cylinder dimensions until in 1895-1896 the maxima were reached in P. Stirling's last batch of Great Northern 8-foot single-wheelers, to which he gave cylinders 19½ by 28 inches, and W. Worsdell's 7-foot 7-inch coupled, which had cylinders 20 by 26 inches.

It was in the year 1896, the one following the historic "Railway Race to Aberdeen" that high-water mark was reached in British railway speeds, from which there was a lamentable



A GREAT NORTHERN SINGLE-DRIVER. DRIVING WHEELS 8′ 1½″ CYLINDERS, 18″ X 28″. PERIOD OF 1870



GREAT WESTERN RAILWAY 7-FOOT SINGLE-WHEELER OF THE YEAR 1870. CYLINDERS, 18″ X 24″

AN EARLY SINGLE-WHEELER ON THE LONDON & NORTH WESTERN RAILWAY

ebb in the subsequent years, 1897-1900, until at the end of the nineteenth century Britain had fallen from her position as first among the nations of the world, in respect of railway speed, to a very bad third,—America and France holding the first and second places by a wide margin of difference.

Curiously enough it was just on the eve of this great British retrogression that her locomotive engineers seemed to begin to awake to the need of increased capacity for steam generation. I do not mean to say that the astonishing developments in respect of booked average start-to-stop speeds which the rival Anglo-Scottish services of 1895-1896 exhibited, was the sole cause of the movement that immediately followed in the direction of boiler enlargements, but it is at least certain that the earliest of the new departures in this respect was the direct outcome of the experiences afforded by the "race" as to what was chiefly needed to enable the West Coast route to hold its own against the shorter East Coast route in the event of the revived competition which the ensuing summer was regarded as certain to bring.

Renewal of "racing" did not come in 1896, but important acceleration did, and it was due to the intelligent anticipation by J. F. McIntosh, of the Caledonian Railway, of this coming certainty, that his justly celebrated "Dunalastair" type of express engine was designed with a boiler of larger dimensions than had ever before been seen on the British standard gauge, the outcome being that in 1896 such speeds were daily maintained by those engines up the terrible Beattock bank,—with its 2 miles of 1 in 88, 2 of 1 in 80, and 6 of 1 in 75, all continuous,—as had never before been deemed possible in ordinary work with normal train loads.

It was a remarkable instance of the wide divergence of thought that may exist between two eminent locomotive engineers, that just when Mr. McIntosh was providing for these improvements by simply en-

larging his machinery of steam production,—the boiler,—Wilson Worsdell was seeking to attain the same end by an exactly opposite road. He preferred to leave his machinery of power production (the boiler) practically unaltered, and to seek enhanced haulage swiftness in augmentation of dimensions applied solely to the other departments,—transmission, and operation.

Thus in his two engines Nos. 1869 and 1870, which were constructed expressly with a view to the accelerations in the Scottish services of 1896, he increased his cylinder diameter from 19 inches to 20 inches, and the diameter of his coupled wheels from 7 feet 1¼ inches to 7 feet 7¼ inches, in each case with somewhat dubious advantage.

But the winter of 1896 brought the great retrogression in British railway speeds to which I have already referred; and for some years thereafter, until in fact the first year of the new century, 1901, Great Britain was content to remain, as I have said, a bad third in this respect. As the 7-foot 7¼-inch North Eastern engines were built expressly for the purposes of acceleration, they were never multiplied.

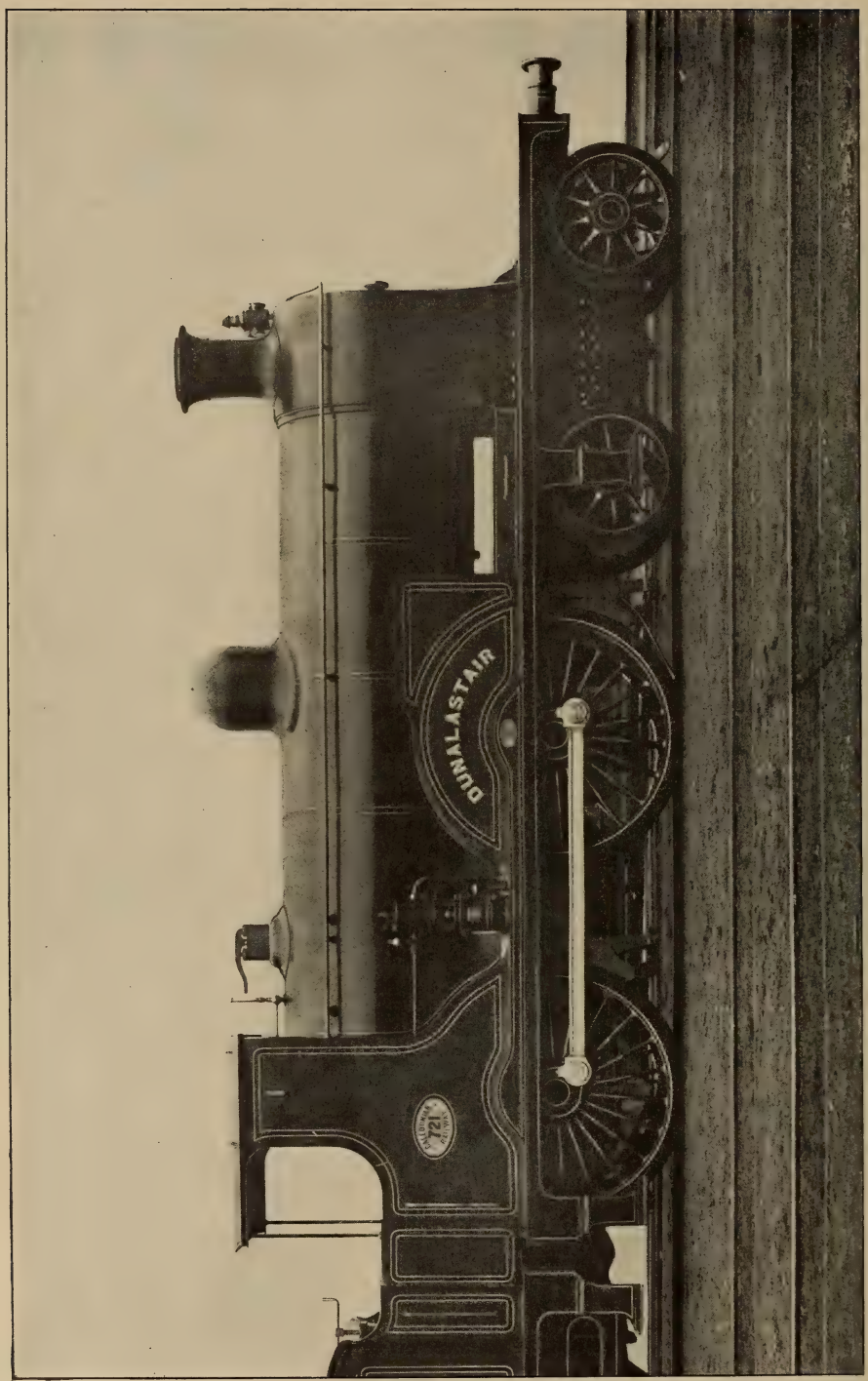
On the other hand, the North Eastern engines also built by Mr. Worsdell, Nos. 1871, etc., which were virtually identical save in having the coupled wheels 6 inches smaller, and cylinders half an inch less in bore, and which differed little from the standard "1620" class, came out in considerable numbers, but, having boilers possessing only 1212 square feet of heating surface, were often unable to work the heavy Anglo-Scottish East Coast traffic between York and Edinburgh without pilot assistance, owing presumably to insufficiency of steam,—in other words, of boiler power.

I have traced at this length those developments on the North Eastern Railway as regards the phases of transmission and operation, besides referring pointedly to the Caledonian in connection with the development of power production, because these two railways,—and I should add the Great Northern and the Lancashire & Yorkshire,—have in a large degree taken the lead in the inauguration of the most recent developments with which I am about to deal.

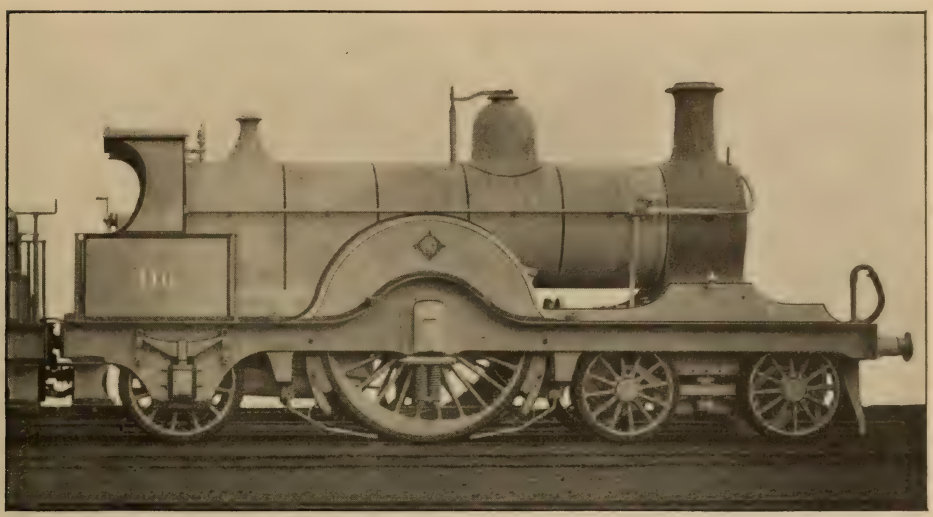
Thus, while Mr. McIntosh was the pioneer with larger boilers in the case of the eight-wheeled four-coupled or 4-4-0 class, H. A. Ivatt on the Great Northern brought out the earliest of all British "Atlantics" (or 4-4-2 class) the well-known No. 990, and on the Lancashire & Yorkshire J. A. F. Aspinall initiated a new departure with an "Atlantic" having a boiler with more than 2000 square feet of heating surface and inside cylinders, while Mr. McIntosh's originally unequalled "Dunalastair" boiler, 4 feet 8 inches in diameter with 1400 square feet of heating surface, soon developed into the gigantic boiler of his eight-coupled mineral class, and of his "50" class of six-coupled expresses, 5 feet 6 inches in diameter, and with 2500 square feet of heating surface.

Thus, within a relatively short period, British practice has so rapidly advanced that whereas only those few years ago heavy express engines rarely possessed more than 1100 or 1200 square feet of heating surface, now it is very rare to find any new express engine built for the principal long-distance, heavy-traffic lines that has not well over 2000 square feet, while up to the present date six engines have been built in Britain and two imported whose heating surface exceeds 2700 square feet, one indeed having as much as 3010 square feet.

Further, it may be noticed that the increased heating surface has not been obtained merely by multiplying the tubes. The old fallacy of tube overcrowding has long since become extinct, and it is recognized that the judicious disposal of tubes is of far more importance than their mere number or superficial area. Thus all



STANDARD CALEDONIAN EXPRESS TYPE. PERIOD OF 1896. DRIVING WHEELS, 6′ 6″. CYLINDERS, 18½″ X 26″



MIDLAND RAILWAY SINGLE-DRIVER EXPRESS. DRIVING WHEEL DIAMETER, 7′ 9″. CYLINDERS, 19½″ X 26″. PERIOD OF 1895

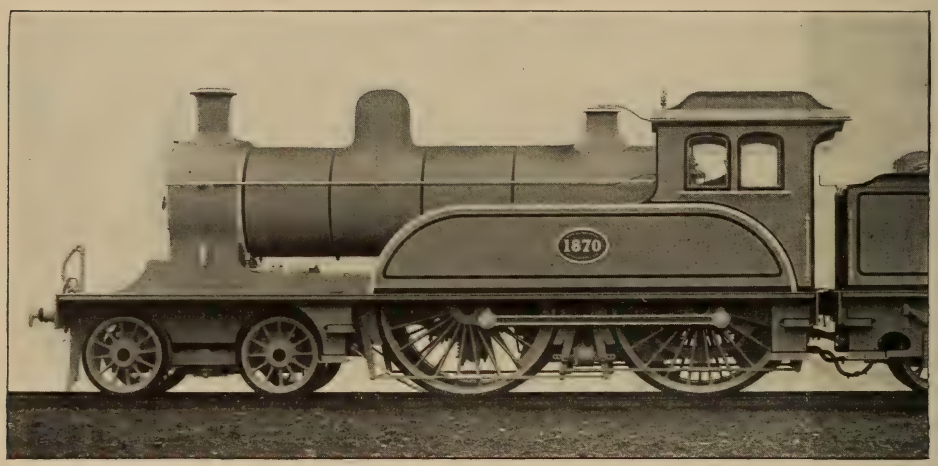
the newest boilers are of very large diameter, often increasing toward the fire-box where abundant steam space is of the chief importance.

Most of the latest boilers equal or exceed 5 feet in diameter and a large number measure up to 5 feet 6 inches. The two latest French compounds imported for the Great Western Railway have 2755 square feet of heating surface, the largest yet seen in Great Britain except in the solitary instance of James Holden's Great Eastern "Decapod," which has 3010 square feet. The five four-cylindered bogie engines, 4-6-0 class, recently built by Dugald Drummond for the London & South Western Railway, come third with 2727 square feet. H. A. Ivatt's latest Great Northern "Atlantics," and J. F. McIntosh's eight-coupled mineral goods engines have 2500 square feet, and his No. 49 and No. 50 passenger expresses, 2400 square feet; the engines of the "Atlantic" type just provided by D. Earle Marsh for the London, Brighton & South Coast Railway have 2473 square feet. G. J. Churchward's "4-4-2" and "4-6-0" and "2-8-0" classes on the Great Western have 2400 square feet; Mr. Aspinall's inside-cylindered "Atlantics" on the Lancashire & Yorkshire have 2052 square feet; and G. Whale's "Precursors" and "Experiments" on the London & North Western have 2009 and 2041 square feet, respectively; Mr. McIntosh's "Oban" class (4-6-0) have 1950 square feet, while J. G. Robinson's 4-5-2 and 4-6-0 express types on the Great Central have 1931 square feet, and J. Manson's 4-6-0 class on the Glasgow & South Western, 1850 square feet; and large number of other relatively recent engines, including both Mr. Worsdell's North Eastern classes of six-coupled bogies and Mr. Churchward's Great Western "City" and "County" classes, have over 1750 square feet.

These instances exhibit in a very strong light the prevalent tendency of the day, which is to magnify to the utmost possible extent consistent with the limitations of the British loading gauge, the capacity of the principal item in the steam generating apparatus, viz., the boiler. And it is noteworthy that with all this vast enlargement of the boiler, only one locomotive type furnishes an instance of the enlargement of the cylinders above the point reached ten years ago, that single instance being

W. Worsdell's "Atlantic" North Eastern type, which has cylinders of a magnitude hitherto unparalleled in British practice, namely, 20 by 28 inches.

There is yet a third department of a locomotive's machinery, that of operation,—the wheels. It would be



NORTH EASTERN SPECIAL EXPRESS TYPE. PERIOD OF 1896. DRIVING WHEELS, 7′ 7″. CYLINDER, 20″ X 26″

idle to institute any comparison between the relative importance of these various departments in a locomotive, because all are essentially interdependent and alike individually and collectively; but it is clear that the possession of unlimited power in the productive and transmissive portions of a locomotive would be utterly valueless as regards haulage and speed were it not converted into operative force through the medium of the wheels resting upon the rails. Now, it is in connection with the wheels of our locomotives, those at any rate that represent the actual feet or legs with which a locomotive "walks," that the most noteworthy recent modifications have taken place in what may be termed the arrangement or the plan of the engines.

Once more glancing far backward we find in the earliest days of railways, all engines running on four wheels,—passenger engines with single drivers, goods engines with all four wheels coupled. Next, fifty years ago, with very few exceptions, all the passenger engines ran upon six wheels, one pair usually being the single drivers, occasionally the two rear pairs coupled, and the single wheels being usually from 5 feet 6 inches to 7 feet in diameter, the coupled wheels 5 feet to 6 feet 6 inches, the goods engines having all six wheels coupled, usually from 4 feet 9 inches to 5 feet in diameter. Twenty years later the goods engines had undergone but little change save in the way of slight enlargement of boilers and cylinders; passenger engines were, as a rule, still six-wheeled and had wheels of much the same size as before, but had slightly more powerful boilers and considerably more powerful cylinders.

Twenty years yet later, i. e., in 1895, the changes still were relatively small. But then set in that great wave of locomotive development whose effects are now to be seen with such prominence in almost every direction on British railways.

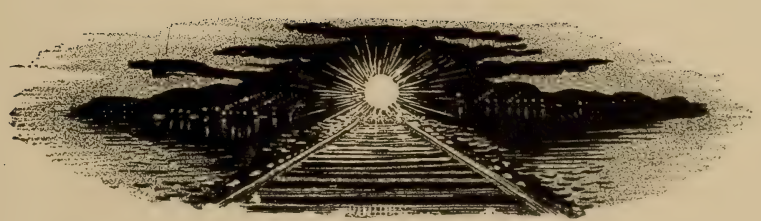
Its predominant characteristic consists in (1) the enlargement of boiler power, (2) in the reduction of driving wheel diameter, and (3) in the increase of adhesion weight by multiplication of coupled wheels. Thus

while 2000 to 2500 square feet of heating surface are becoming as common as were 900 to 1200 square feet only a very few years back, the value of this nominal generation power is being largely enhanced by various ingenious devices.

On the Great Western, Mr. Churchward expands his boiler barrel outward as it nears the fire-box so as to obtain the largest possible steam space in that most favourable neighbourhood. Hence we get the "wagon-top" or "taper" or "coned" boiler which, though long in use in America, has been very tardy in making its appearance in Great Britain. On the London & South Western, Dugald Drummond has introduced his water-tube fire-box in which the water of the boiler is conveyed in 2½-inch tubes right through the furnace itself, with obvious advantage in the direction of quick ebullition and effective circulation. On the Great Western, Great Eastern, Midland, Great Central, and Lancashire & Yorkshire, the Belpaire fire-box is extensively employed with recognized advantage as regards facility of steam generation. Augmentation, too, of steam pressure, is virtually universal.

Passing over the three du Bousquet—de Glehn compounds improted from France which have 227.5 pounds steam pressure, a pressure of 225 pounds per square inch is employed by Mr. Churchward in a number of his new 4-4-2 and 4-6-0 express engines. R. M. Deeley uses 220 pounds in his ten newest Smith compounds. Others have 200 pounds, but no new locomotives of any class have less than 175 pounds. D. Earle Marsh, the new locomotive superintendent of the London, Brighton & South Coast, uses 200 pounds. So do W. Worsdell (North Eastern), G. J. Churchward (Great Western), W. P. Reid (North British), and J. F. McIntosh (Caledonian).

To be Concluded in the May Number



THE MENACE OF PRIVILEGE

AN ESTIMATE OF HENRY GEORGE, JR'S RECENT BOOK*

By R. W. Raymond

THIS book represents the general view that, in America, monopoly and the money power are making the poor poorer, as well as the rich richer; and that a radical reconstruction of American institutions is necessary, the governmental system of representative democracy and the federal union of States, on the one hand, and the common-law system of free, responsible and enforceable individual contact, on the other hand, having miserably failed.

Like his illustrious father, Mr. George regards the private ownership of land, together with the manner of its taxation, as a primary source of all these alleged evils; but he goes much further, I think, than his father would have gone, in his attack upon the existing social order. The writings of the father, whether his theories were right or wrong, deserved and received respectful attention from political economists; this utterance of the son belongs to a totally different category.

It is a fierce polemic, in the preparation of which the author has apparently taken no pains to verify his assertions of fact. Everything that came to his hand,—newspaper reports, rumours (contradicted or uncontradicted), inferences, suspicions, gossip and scandal,—he has eagerly employed without question, if only it tended to render odious the persons, enterprises, parties, institutions, laws or opinions against which he is waging war. He is as ready to throw mud as stones. The alleged faults and vices of particular individuals are, for his purpose, as pertinent evidence as the alleged revelations of widespread social conditions; and, in either case, the allegation is quite enough for him as justification for its use, without further inquiry as to its truth. His ethical offence is only aggravated by the scandal-monger's "It is reported," or "I do not accuse or blame the man. I only point him out!"

There is an immense volume of such belligerent literature; and the serious student is greatly embarrassed in dealing with it. For it undoubtedly contains facts, arguments and suggestions not without value; but the labour of sifting it to obtain them is too great to be repaid by the residuum thus extracted. As a specimen of the things which many people believe, and the way in which many people reason, and therefore as indicating a factor of which the student and the statesman must take account, such books are doubtless important. But as contributions to a thorough knowledge of present conditions, or of present evils or perils and their remedies, they have little or no practical value. For life is short and books are many; and ordinary people, seriously inves-

* The Menace of Privilege. A Study of the Dangers to the Republic from the Existence of a Favoured Class. By Henry George, Jr. Published by the Macmillan Co.

tigating a given subject, must needs confine themselves, if possible, to the examination of trustworthy evidence. For such people, the rule is almost imperative, that, when any witness is shown to be, in any particular, not merely careless, but recklessly and deliberately disingenuous, his testimony may be entirely disregarded,—even though sometimes, consciously or unconsciously, he may have told the truth.

Mr. George's book deals with unquestionably important subjects; it is written in excellent English, and it contains many ideas and suggestions worthy of notice. To expose its innumerable misstatements, suppressions and distortions of fact and its errors of reasoning a book of equal size would be required. Such a book would contain the corrections which the author himself should have made before publication. Whether this detailed refutation would be worth while or not, it is manifestly beyond the sphere of a periodical journal. All that I can here do (and I do it, without aspersing the sincerity of Mr. George, for the simple purpose of defining the true character and weight of his work), is to point out some features of this book, from which, I think, its nature and value can be fairly inferred.

The first of these features is the treatment given to labour-unionism, as an element of the problem under consideration. This discussion, while presenting a specious appearance of frankness, ranks the modern labour union as a "resistance to privilege," instead of an audacious assertion of privilege, and practically ignores the fact that the present national federation of labour unions is the most stupendous organized movement against industrial liberty and the rights of citizens ever known in human history; that it maintains at State and Federal capitals a perpetual "lobby" for the intimidation of legislators, in comparison with which the occasional lobbying of capitalists is insignificant; that it has secured, through this bulldozing agency, the specific exception of labour unions in many statutes, prohibiting other citizens from acts thereby permitted to such unions; that, for the anthracite regions of Pennsylvania, it has thus obtained a law, practically preventing the employment, in whatever emergency, of miners, however skillful, to take the place of its members; that it has achieved a practical monopoly of the importation of skilled labourers from abroad, through the Federal law (administered by labour-unionist commissioners), which forbids the admission into the United States of a man who knows where he can find employment, while it admits the man who does not know, but (if he be a member of a labour union) will find out, within an hour after he has been passed as unobjectionable; that it antagonizes candidates for office, if they do not have the "union label," duly paid for, upon their political circulars; that it justifies and practices, through the "boycott" and the "sympathetic strike," the injury and ruin of employers totally innocent of blame, or even of knowledge, concerning its claims or controversies; that, though comprising, at the maximum of its fluctuating membership, not more than 10 per cent. of the workers in the "organized" trades which it represents, it ostracizes as "scabs," and pursues with unrelenting, vindictive hostility (whenever this course seems politic) the other 90 per cent.; that it limits the employment of apprentices, and discourages the education of skilled workmen in trade-schools; that it does not hesitate to subject the public to inconvenience and distress for its own selfish interest; that it denounces as tyrannical the ordinary, decent enforcement of order by courts, police, militia or regular troops, while its operations are almost invariably attended by disorder and crime, of which it disclaims the responsibility, yet accepts the benefit;

that it condemns as treason the attempt of any workman to obtain recognition or promotion by superior skill or loyalty; that its members are, certainly in many cases and probably in all cases, bound by oath to an allegiance and obedience superseding all other obligations;—in short, that it aspires to become, and has to no small degree become, an "imperium in imperio," superior to all other authority whatever.

If there exist among us to-day any really dangerous "privileged classes," fortified in their arrogance by statutes, and supported by time-serving politicians, as well as sentimental philanthropists, the present labour union class should head the list. Yet Mr. George puts it in the opposite list, and falsifies history by describing it as a defensive movement, whereas, as an element in the present situation, it is everywhere and always aggressive, and has encountered only within two or three years past the opposition of anything like a commensurate organization of employers..

This omission to give to the national organization of modern labour unions its proper place among the dangerous "privileged classes" may be charitably considered as an honest error of opinion, to be amicably controverted. But Mr. George's book furnishes abundant proof of his willingness to support his opinions by a reckless manipulation of evidence. Whoever would apply this test with swift and certain result may turn to his account of the Cœur d' Alene "labour troubles" of 1899,—an almost wicked distortion of the facts, ignoring the anarchy and crime which imperatively called for Federal intervention and martial law, and tacitly endorsing the methods and proceedings of the worst gang of organized robbers, ruffians, and assassins that ever terrorized a community.

Since Mr. George gives a professed summary of the results of an investigation by the Committee of Military Affairs of the United States House of Representatives, he must be supposed to know the facts which he does not state, as well as those which he selects and emphasizes. He must know that the investigation, instigated by a sympathizer with his party, made by a committee including other sympathizers, and expected to furnish ammunition for an attack upon the Federal administration, ended in a complete collapse of that purpose, and an approval by the committee of the action of the government.

He must know that the politicians who originated the promising raid abandoned it in disgust. He must know that this outcome was mainly due to the frank and manly evidence of the "Populist" governor of Idaho, elected as an opponent of corporations and "privileged" classes, yet regarding himself as bound by his oath of office to maintain public order and protect life and property in his State. He knows now, at all events, that Governor Steunenberg has paid the penalty of his fearless discharge of duty, having been brutally assassinated, in accordance with repeated threats from the organization which he defied and defeated.*

Concerning this brave man, the central figure of the whole proceeding, and of the Congressional inquiry from which Mr. George quotes so freely what happens to suit his purpose, he has nothing to say, not even so much as a mention of the Governor's name; and he quotes nothing from the Governor's dramatically and overwhelmingly conslusive testimony. Concerning the outrages of 1899, or the previous reign of terror of which they were a revival, he has only to say that "at a place called Wardner, there was some kind of a demonstration on

*Since this article was written, the arrest and confession of the murderer, and much additional evidence going to prove the complicity of labour union leaders in this crime, as well as others of the same nature, together with the indictment of several of these leaders, have emphasized the statements here made.

the part of the miners, and the concentrator mill of the Bunker Hill mine was blown up with powder by, it is supposed and charged, some one on the workmen's side, although no proof of this seems ever to have been found!"

An author capable of offering such a summary of the Cœur d' Alene case is not fit to be trusted as a witness; and even an advocate capable of imagining he could strengthen, by adducing that case, his condemnation of the use of the army of the United States, in the last resort, to sustain the authorities and protect the citizens of a State, is not entitled to a respectful hearing.

I call attention to this instance* as apparently involving a deliberate and conscious suppression of facts, in the spirit of a partisan orator, whose business it is to present his own side only. If he thereby misleads his readers, "caveat lector!" There are those who can present the other side, if they choose: let them attend to that duty. Every page of Mr. George's book shows that this is his habit of thought in small matters, as well as great.

His practice, however, is modified by incidental disclaimers of responsibility, which belong rather to the retailer of gossip and scandal than to the apostle of truth. For instance, in one place, after asking the question, —"What causes the unequal distribution of wealth by which one class is made superabundantly rich, while another, vastly greater, has a hard struggle to get a living?" he proceeds as follows:—

"The will of Heaven, some say. President George F. Baer, of the Anthracite Coal Trust, was credited by the newspapers of the country, in the summer of 1902, during the second great hard-coal strike in Pennsylvania, with writing to a correspondent:— ,

" 'The rights and interests of the labouring man will be protected by the Christian men to whom God, in His infinite wisdom, has given the property interests of the country.'

"*Whether or not Mr. Baer said this* [the italics are mine], it represents the thought, or at least the utterance, of a certain class of privileged people."

The letter of Mr. Baer thus garbled was published in full by "the newspapers of the country"; so that even Mr. George, who habitually adopts this authority as sufficient, has no excuse for his malicious misrepresentation, guarded with a cowardly "whether or not." The further intimation that what Mr. Baer may or may not have said "represents the thought, or at least the utterance" of a certain class, carries the art of insinuation one step beyond sublimity. Nobody could require Mr. George to quote the thoughts of the wicked verbatim. But if he proposes to represent their utterances, why not take an utterance that he can guarantee as authentic? Or are we to believe that all such utterances are representative, "whether or not" they were ever uttered?

The book exhibits also a pretence of literary honesty in quotations and references which will, at first glance, doubtless produce upon many readers the impression of careful research and fair citation. Some of these repeat an old trick. Mr. —— writes a book, based upon "sworn testimony," under which he adduces stories told in court by witnesses for one side, omitting to mention how they were shattered by cross-examination, contradicted by other testimony, or rejected by judge or jury. Miss —— quotes Mr. ——; Mr. George quotes Miss ——; and thus an original slander is elevated by repetition into an "authority," to be accepted by clergymen, philanthropists, reformers, doctrinaires, and demagogues. The way in which such superficial, smart essayists make "authorities" of one another would be

*Mr. George's reference to the Homestead, Pullman, Cripple Creek and other strikes and outrages, are similarly "unfair," in the old sense of that term, and not its modern labour-union sense.

comical if it were not, in its popular effect, so demoralizing.

Mr. George's book is to be chiefly condemned, not because it is essentially an aggregation of all sorts of material, largely gathered from newspapers and magazines, but because this miscellaneous stuff has been arrayed and employed, with no little rhetorical skill and dexterity, to simulate an honest investigation and a comprehensive discussion of the great questions with which the author professes to deal. Already his work has been characterized, by writers who ought to know better, as "a book of first-rate interest and importance," and "a remarkable piece of description and analysis" of "present-day conditions."

What is the thesis which this book professes to maintain? After much rummaging of its inwardly confused and inconsistent (though outwardly, with much pretentious division and subdivision, logically arranged) contents, I can reach no other conclusion than this,—that Mr. George, starting with the private ownership of land as the root of all evil, manages, before he gets through, to come very near adopting the principle of Proudhon, that all "property is robbery."

His father was anxious not to be reckoned a communist or thoroughgoing socialist; and it is likely enough that he would likewise protest against such a classification for himself. In such a protest, he might very well be sincere. In religion, politics and science alike, no distinctions are so passionately insisted upon as the minute ones which the average observer overlooks. But, however Mr. George may object, the effect of his indiscriminate attack upon "Privilege" is an attack upon property.

How he has reconciled his implied condemnation of all legally conferred monopolies (of which class patents and copyrights are the chief representatives under American law) with his own course in copyrighting his book, for the benefit of his privileged publisher, so that no one else can reprint it for twenty-eight years to come, even upon payment to Mr. George for compiling it, must be left to his conscience. We might imagine a time when the (not impossible) immense sale of this work, protected by the odious copyright monopoly, shall have enriched both compiler and publisher, entitling some later member of Mr. George's school to denounce both of them as the bloated beneficiaries of "privilege."

Or, on the other hand, we might imagine a time when, the said sale not having been so large as the work deserved, and the original purchasers having, through an erroneous estimate of its value, sent their copies to the junk-man for ultimate transformation into useful wrapping-paper, the book will have become a rare and costly curiosity, so that the lucky possessor who had omitted to throw it away will be able to obtain for it, from the rich connoisseurs whom it denounces, a price representing not only its intrinsic value, but an "unearned increment," due to an artificial scarcity, resulting in an odious monopoly!

I do not seriously anticipate, however, from Mr. George's monopolistic copyright, acquired as a legal "privilege" for the benefit of his publisher and himself, either of these unhappy effects. On the contrary, I deem it likely that his book will be forgotten, in spite of its earnestness, eloquence and literary skill, because it deals with profound questions in the spirit of partisan prejudice and passion. It is essentially not judicial, but oratorical; and hence it will be ephemeral.

A QUESTION OF GOOD ADVERTISING

By W. D. Forbes

IT is somewhat difficult to give a comprehensive definition of "advertising." In the dictionary it is defined as "to announce," "to publish," "to make known publicly." While this may be correct in a literary way, it is not so commercially, and the recognition of the difference will prevent loss of money.

The mere fact of announcing publicly does not by any means fill the requirements of the commercial advertisement. What is an advertisement for? To get people who have money to give it to you for something which you have to dispose of,—information, or some article, and it makes an enormous difference how and where you advertise. Let us take an example to illustrate:—

EGGS, HENRY SMITH, CENTERVILLE, N. Y.

This is an announcement, undoubtedly, but it is not one likely to attract general attention. The following, however, will:—

EGGS! EGGS! EGGS!

GUARANTEED TO MEASURE ½ FOOT AROUND THE SMALL WAY!

JOHN JONES, CENTERVILLE, N. Y.

It would be fair to say that almost every reader of this advertisement would not believe it, yet it is strictly true. Any ordinary hen's egg will measure almost 6 inches around the small way, and a great many will measure more; but the public does not know this, nor does it think of measuring eggs at all, and a foot is a unit of measurement for large things. This display attracts attention, but it certainly does not inspire confidence, and its value is consequently lessened as people would suspect fraud and would not buy. The first of the two advertisements would, if noticed, be more likely to result in sales than the latter, but the latter is a better announcement.

In both these advertisements there is to be found the main idea of an advertisement, that is, to connect an article and a person's name. Eggs—Smith,—Eggs—Jones. How much this combination of a name and article is worth can be readily understood by recalling such combinations, as, for instance,—

PIANOS	STEINWAY
SOAP	PEARS
CANDY	HUYLER'S
JEWELRY	TIFFANY

The value of this combination of a name and an article is utterly lost sight of by a great many advertisers who overlook this first necessity in advertising.

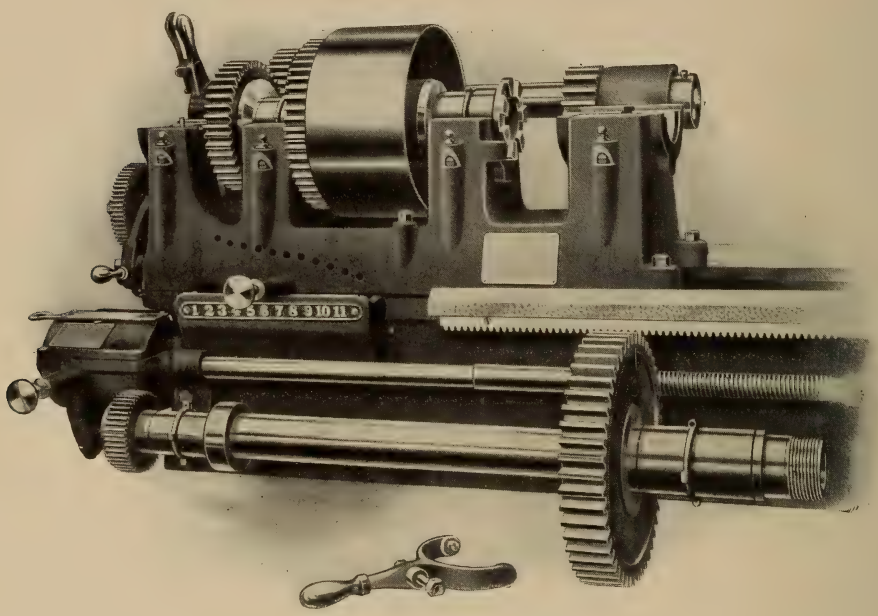
Many go into detail before an impression is made on the mind as to what the central idea or article is. This is especially the case with circulars. If those who read this article will note carefully their daily mail for a short time, they will find numberless folders which have to be read almost through before any connection is shown between the article to be disposed of and the manufacturer or seller. It must be remembered that this class of literature finds its way almost immediately into the waste paper basket, and if no impression is made by it, it represents an absolute waste of money. It is of course necessary and well, at the proper time, to have details noted in full, but the first thing to do is to get the attention, if possible, and with such mail literature the atten-

tion is, from necessity, only momentary, and to make an impression on the reader which is favourable is the first step towards a sale.

It is to be noticed that the fault just stated is usually found in the low-priced postage matter. The one-cent stamp on an envelope does not attract a business man. An unsealed letter is often thrown away without even a glance, but a sealed letter is invariably opened and glanced at, if not read. Look back over your business connections and see if you can trace much or any successful business from the one-cent postage matter that has been received.

A very serious loss arises from the fact that little or no attention is paid to the size of the circulars or matter sent. Some of it is absolutely impossible to take care of by filing for future reference. In one mail a poster 30 inches by 60 inches was received, a card 1½ inches by 2 inches, on which the printing was so fine as to make it difficult to read, and its size would result in its being lost easily, while the size of the poster practically demanded that it should be destroyed. Other cards received in this same mail were illegible, as they were on stiff cardboard, and in transmission had been broken so that they could not be read. In several cases they were received in separate pieces. Rolls of printed matter are often found frayed at their ends so that they are not only unsightly, but difficult to handle without tearing. Out of twenty-six letters, only one made any favourable impression whatever on the receiver. The others were annoying, if anything, since looking them over occupied valuable time. In one year's business these one-cent advertisements mount up to a vast number, showing a total loss of money, even though this expression, "total loss," is not intended to mean here that no sales were effected, but that the amount of sales, when compared with the cost of making them, showed no satisfactory commercial relations.

After much thought on the subject of one-cent matter, it is believed that



A PERPLEXING LATHE ILLUSTRATION

it can be made of value by using a standard size of index card on which the sender's name and specialties are clearly shown. Such a card could be readily filed and probably would be if on the proper quality of paper, as it would require almost no effort to do so. A second card could follow this for a cross index, and still other cards could be sent to call attention to article after article in a systematic way. A very large amount of one-cent matter received is of value, but because it is either of an inconvenient size or too "wordy," is lost. The card system, as suggested, would certainly decrease the likelihood of loss.

It is perfectly evident that if a person has, say, gold dollars for sale and wants to dispose of them at 80 cents, and no one knows it, sales will not be made, and the first thing which has to be done is to attract the attention to the fact that they are for sale. The next step would be to go into such detail as would interest those who desire to purchase.

There are two distinct styles of advertising. One must be used for the purchasing agent who desires little information except price, weight, and time of delivery. The second should have nothing to do with price, but should go into the fullest details, as the user of the article must be in possession of such information, and, being interested, would be absorbed in it. This style of advertisement would go into the hands of the foremen or superintendent, or perhaps one of the workmen.

Up to the present, only advertising by post has been considered, and although it is only one of the many outlets for wasting money it is believed that it is the most prolific in this respect. But there are other methods of injudiciously using money in attempting to make sales. The illustration opposite represents one of these. To most people the cut is confusing in the extreme, and is misunderstood. What is shown? A lathe, the product of a maker of acknowledged reputation, but the tool is out of the ordinary, and is what might be called a special construction which the illustration does not explain.

In talking with many people who looked at the illustration, not one was found who really understood the design, and the criticisms were varied. One person said he would not buy a lathe with a back gear hung in front on the bed as shown, and that such "skinny little" bearings would wear out at once.

When the cut was explained to him, his answer was,—"How am I and others to know that these little things I took for bearings were either oil rings or temporary supports?"

Others said,—"How can I tell that the gears shown on the front of the bed were not drawn to the same scale as the rest of the illustration?" "How was I to surmise that there was any clutch at the back of the large gear?" "I think I am right in stating that the illustration is wholly misleading. I have known lathes for thirty years, and such an arrangement as shown is novel, but without a verbal description, or else some more illustrations, it is quite impossible for me or anybody else to understand what the advertiser wants us to know."

One thing is certain, that the illustration attracts attention, but not, as previously noted, advantageously. It is really misleading.

Referring again to the first advertisement of eggs, it represents the use of a very small space in an advertising medium. Broadly speaking, a small space is insignificant, and a large space prominent, but this idea can be carried beyond reason. In turning back to trade papers of twenty years ago it will be noticed that there are comparatively few full-page displays. The advertisements grew gradually larger and larger until now it would seem that the pendulum in some cases had swung far beyond reason. After all, however,

more money is certainly wasted by small, insignificant advertisements than by large ones.

The selection of the class of journal or periodical is of great moment to advertisers. While eggs are used by almost every reader of CASSIER'S MAGAZINE, it is a question whether an advertisement in it of eggs would effect sales, the reason plainly being that its readers do not buy them in quantities, but get them locally. This illustration shows a common source of loss from an injudicious selection of the medium

It would seem reasonable to say in concluding this article that cheap post parcels do not pay, for the reasons that the size of such literature is inconvenient, that it is not concise enough, and that there is a strong prejudice against it. It can also be said that an advertisement which is not clear is of little value, as it creates an unsatisfactory feeling, and the sentiment that possibly the article itself may not be really any better than the display.

It should be borne in mind that the primary object of an advertisement is to fix articles and names so firmly in the minds of the buying public that they become interchangeable.

REINFORCED CONCRETE FOR POWER STATIONS

By H. S. Knowlton

THE rapidly extending use of reinforced concrete in engineering construction is one of the most interesting developments of the present day, and although designers have still much to learn about the behaviour of this typically modern material under stress, there is not the least doubt that the applications of reinforced concrete are destined to increase in both number and variety during the next few years. Several reasons for this prediction exist, and of these, the diminishing supply of timber and the high cost of skilled labour are perhaps the two most important. Power house work is a representative application which has thus far been developed to only a comparatively limited extent, but which holds excellent prospects for the immediate future.

In a general way, anything which can be accomplished with steel skeleton construction is possible with reinforced concrete, and usually at a reduction in cost that is well worth while. It is not uncommon to save from 20 to 30 per cent of the investment charge in this way, although local conditions vary so much that no general figure is applicable. In cases where no labour troubles occur to prolong the construction period, and where the bids of the steel makers are moderate, followed by good deliveries, the margin will very likely be much less.

A great point in favour of reinforced concrete, however, is the ease with which it may be manipulated. All ordinary construction can be executed by unskilled labourers, provided competent supervision is maintained. The cost of the building in a power house layout, is usually only a very small percentage,—frequently only 3 or 4 per cent.,—of the total cost of the plant, but in these days even a small percentage is well worth saving, if it can be done without injury to the final operating economy of the installation.

On account of the fire hazard the use of timber for power house construction does not receive much en-

couragement from engineers in charge of important installations, and in many communities, particularly those of the more populous kind, the erection of wooden buildings for the housing of boilers, engines and generators is prohibited. The so-called mill or slow-burning construction of the insurance interests may be very satisfactory for general industrial purposes, but very few important power houses are built in this way. In localities where timber is fairly cheap, in the American Northwest, for example, a hydro-electric plant might be constructed with heavy timber floors, walls, and roof, to the temporary satisfaction of its owners; but the more permanent and fireproof constructions of brick and steel, or concrete-steel, are commonly employed for the most important power house undertakings.

A wooden structure begins to depreciate on the very day it is opened for service, and, to a lesser degree, brick and steel buildings follow the same course. The life of a brick and steel power house is doubtless long enough for all reasonable requirements,—from fifty to seventy-five years ought to be secured with proper construction and maintenance; but the life of a reinforced concrete power house should far exceed these figures. As far as present knowledge indicates, the depreciation of a reinforced concrete power plant building, if designed with due regard to the loads which the members must carry, is so small as to be beyond the scope of accurate estimate.

It is more than probable that within the life of any well-designed brick and steel power house building the methods of generating electricity will be improved so much that the building will become unsuited for power house uses, so that any choice of reinforced concrete should rest on other considerations than its exceedingly long life in comparison with brick and steel. The erection of a masonry cathedral, which will be suited to the needs of many scores if not hundreds of years, is a far different matter from the design of a power house for commercial service, which may become obsolete in ten or fifteen years at the latest.

The fact that reinforced concrete construction can be carried on effectively with unskilled labour tends to reduce the cost of building through the resulting freedom from the delay and expense of prolonged strikes. Unskilled labour has never yet been organized effectively, and in these days of industrial unrest it is very difficult to carry out building contracts on a large scale with skilled labour without much uncertainty as to when the work will be completed.

The foundations of boilers and generating machinery in large plants are now almost entirely of concrete, and it is a question if a considerable amount of valuable space could not be saved in power house construction if concrete-steel instead of plain concrete were employed in these foundations. It is often a difficult problem to locate the condensing equipment and basement piping, on account of the space taken up by plain concrete or brick foundations. Walls, floors, and compartments can be made much thinner with reinforced concrete construction, for the same supporting strength. Given, a plant designed with reinforced concrete upon a factor of safety of four or five, the aging of the concrete only serves to increase the stability of the construction, and tends to absorb the vibrations of the machinery with greater effectiveness. The possibility of thin walls and columns enables a large amount of window space to be secured, and all the advantages of a liberal supply of natural light to be enjoyed. The decreased fire risk should lend itself toward a substantial reduction in insurance premiums, and in the direction of simple ornamentation much can be done with reinforced concrete to improve upon the present severely utilitarian designs found in so many plants.

It is most important for investors in reinforced concrete construction to realize that designs of this kind are properly the work of a specialist. It has well been said that the essence of good design is to adapt reinforced concrete to successful use in thin and light masses.

Unless, however, the designer is thoroughly skilled in the calculation of stresses and strains, and supplemented in knowledge by positive ideas as to the behaviour of the material in service, it is dangerous for him to execute important work. It is vitally important that the mechanical union between the concrete and the steel be first-class, and to this end the use of steel free from loose scale, and of cement of plastic rather than granular constitution is to be recommended. Ample time must be given for the concrete to set before loads are placed upon it. Experimental tests upon typical beams with known weights of pig-iron are often very desirable.

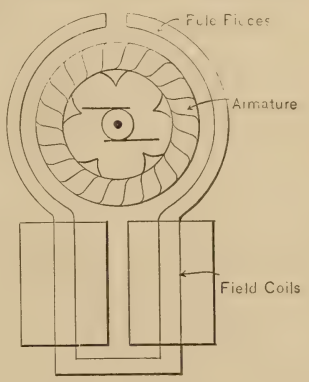
The literature of reinforced concrete is already voluminous, and a great mass of experimental data is available for the designer to study. At the same time the knowledge we possess of the stability of steel construction is considerably greater than our knowledge of reinforced concrete, which for some years to come is likely to remain a fertile field for investigation and analysis.

Current Topics

It occasionally happens that the predictions and theories of mathematicians and scientists are woefully upset and contradicted by actual results. Every one is familiar with the story of the editor who, in the days of Stephenson's early experiments in railroading, predicted that a speed of more than twelve miles an hour by rail would be impracticable if for no other reason than that the human system would not withstand travelling at a higher rate of speed. In the early days of steam navigation also Dr. Lardner delivered an address before a scientific body, in which he maintained that transatlantic steam navigation was impracticable, mainly because of the inability to provide room aboard ship for the coal that would be necessary for the voyage. The meeting had scarcely adjourned before the news arrived that a ship had just

completed a transatlantic trip under steam. In another case a number of individuals seriously promulgated their belief that it would never be possible to successfully lay a cable across the Atlantic, because, as they said, the density of the water below a certain depth would be so great that the cable would not sink to the bed of the ocean. Regardless, however, of these predictions, the cable promptly sank to the bottom of the sea. At that time also, it may be noted, the greatest ocean depths in which cables were laid was only about 16,404 feet. Within the past year a cable has been successfully laid by a German company in the Pacific Ocean in the vicinity of the Luikin Islands at a depth of 26,246 feet. In still another instance the author of a well-known textbook on telegraphy, published in the sixties of the last century, expressed the opinion that while the idea of duplex telegraphy, or the sending of two messages at once over one wire, was very beautiful in its way, it must be looked upon as little more than a feat of intellectual gymnastics, and quite useless from a practical point of view. Within less than a decade after the publication of this opinion not only was the duplex telegraph in practical operation, but quadrupled telegraphy, or the sending of four messages at once over one wire, was also an accomplished fact. Notwithstanding that instances of this kind could be multiplied, there are still to be found people ready to write themselves down to posterity as erring prophets, and so it will doubtless be to the end of the chapter. Fortunately, however, for the sake of progress, there are, on the other hand, always optimists enough to offset the discouraging views of the pessimists.

For several years the trend has been in the direction of larger and larger units of electric generators and motors, until to-day units of 5000 and 10,000 kilowatts are not uncommon, and the end is not yet in sight. By way of contrast to machines of these enormous dimensions, a brief description of a series-wound motor of relatively microscopic dimensions may be of interest. Motors of this type are in actual service in the operation of gas pressure indicators manufactured by Jules Richard, of Paris. The accompanying sketch illustrates the motor in its



A 2-INCH ELECTRIC MOTOR

actual size. The field coils are each three-quarters of an inch high and half an inch in diameter. The armature coils are 0.6 inch long, and rotate in a circular space of one inch diameter. The distance from the base of the machine to the top of the pole pieces is less than two inches. The field has two separate coils, wound oppositely. The direction of rotation of the motor is reversed by a device which sends the current through one or other of the field coils at will. The armature coils from brush to brush measure approximately 20 ohms. The field coils have a resistance of about 15 ohms. The motor runs freely at a high rate of speed, with five dry cells, at an expenditure of about one-fifteenth-hundredth of a horsepower. By means of gearing, not shown in the sketch, the motor rotates a pointer on a dial in either direction, corresponding with the rise

or fall of gas pressure, and at the same time it causes the transmission of current pulsations to a distant point, which pulsations, in turn, operate another pointer that indicates the gas pressure at the transmission station.

THE discovery of a direct method of producing artificial cold by electrical means would, according to Col. R. E. B. Crompton, mark the solution of a problem of real moment to both suppliers and users of electrical energy. In a lecture on "Unsolved Problems in Electrical Engineering," which he delivered several months ago before the Institution of Civil Engineers, he remarked that while, of course, we can now produce artificial cold by connecting an air-compressor to be driven by an electric motor, and by expanding the air into a cold-storage chamber, the method is costly and cumbrous. Probably something may be done by a well-designed high-speed air-compressor, but the real solution we are looking forward to is a direct method of producing cold from the electrical energy in supply mains, and this probably is a problem for the electrochemist, as we may conceive the apparatus taking the form of a reversed battery abstracting heat from the surrounding air.

AN internal combustion engine plant in combination with a steam-turbine plant offers the most attractive proposition for efficiency and reliability to-day, with the possibility of producing the kilowatt-hour for less than one-half its present cost. This is the conclusion arrived at by H. G. Stott, superintendent of motive power of the Interborough Rapid Transit Company, of New York, after a careful study of power plant economies, and presented in a recent paper before the American Institute of Electrical Engineers. The steam turbine and gas engine combination also would overcome at once the only valid still existing objection to the gas engine for power house service, namely, its inability to carry heavy overloads and still run economically at average loads. As to this, Mr. Stott said that some time ago, while watching the effect of putting a large steam turbine having a sensitive governor, in multiple with reciprocating engine-driven units having sluggish governors, it occurred to him that here was the solution of the gas-engine problem, for the turbine immediately proceeded to act like an ideal storage battery, that is, a storage battery whose potential will not fall at the moment of taking up load, for all the load fluctuations of the plant were taken up by the steam turbine, and the reciprocating units went on carrying almost constant load, whilst the turbine load fluctuated between zero and 8000 KW. in periods of less than ten seconds. A steam-turbine unit can easily be designed to take care of 100 per cent. overload for a few seconds; and as the load fluctuations in any plant will probably not average more than 25 per cent., with a maximum of 50 per cent. for a few seconds, it would seem that if a plant were designed to operate normally with 50 per cent. of its capacity in gas engines and 50 per cent. in steam turbines, any fluctuations of load likely to arise in practice could be taken care of. By utilizing the waste heat in the gas engines for the purpose of assisting to make steam for the turbines, approximately 37 per cent. of the total heat lost in the gas engine can be saved, and the economy of the steam part of the plant will be raised to 25 per cent.

THE view is sometimes expressed that the adoption of high-speed automatic telegraph systems would lead

to a much larger use of the telegraph, which would make lower telegraph rates possible and still leave large profits for the operating companies. This view, however, has not been borne out altogether in practice. In Great Britain, where the tariff on telegrams has been reduced very considerably under government control, there has been a large increase in the use of the telegraph, but still the service is not yet self-supporting. In Germany, where the government also controls the telegraph, the rate for 20 words is 6 pence, as against 6 pence for 12 words in Great Britain. Notwithstanding the lower cost of telegraphing in Germany than in Great Britain, 228 telegrams per 100 persons are sent annually in Great Britain to 81 telegrams per 100 persons in Germany, this indicating that low rates alone do not lead to the extensive use of the telegraph.

Some interesting information along these general lines was recently presented by Mr. John Hesketh, electrical engineer to the Queensland postal telegraph service, in a report giving the results of his observations in Great Britain and the United States, from which countries he recently returned. In that portion of Mr. Hesketh's report covering the subject of machine telegraphy, that is, high-speed automatic systems, he says:—"In England every promising new system is given a complete trial under the supervision of the inventor, if he desires. The systems, therefore, which have survived in Great Britain are those which have most worth. It is noteworthy that of the trials so far completed the apparatus which has survived and demonstrated its usefulness to the fullest extent is the Wheatstone system. Now, although the Wheatstone system has survived, and is used practically to the exclusion of every other automatic system, it is remarkable that it is not now worked up to the highest possible speeds, nor is any effort made to increase speeds for normal working. The reason for this was given by Mr. John Gavey, technical head of the British postal telegraph systems. It appears that a special departmental committee was appointed to make recommendations as to certain traffic and technical matters in connection with the telegraph department. This committee reported that it was not advisable to work Wheatstone over 200 words a minute, for the reason that when this speed was exceeded the delay to business was simply transferred from the transmitting to the receiving end. It was a practicable impossibility to so staff a Wheatstone line that the slip could be written up with no delay if the lines were worked at maximum speeds. In other words, the experience of this great department is to the effect that to try after excessive speeds is a practical error, and that it is better to adopt such reasonable speeds as 200 words a minute rather than try after 600 or more, by systems which depend upon the transcription of slip. The same argument does not apply to direct-printing systems. This decision is the more remarkable, seeing that speeds as high as 600 words a minute have been attained by means of the Wheatstone system, and are now practically abandoned, although within easy reach on open aerial lines."

Perhaps the most important feature of Mr. Hesketh's quoted remarks is that contained in the statement that the practical objection to the utilization of high speeds does not apply to direct-printing telegraph systems. The force of this statement will be self-evident on consideration, since direct-printing telegraph systems receive the telegram ready for delivery in Roman letters, and consequently the services of transcrib-

ing clerks or copyists are not necessary, and the delay of transcribing messages and the opportunity for errors on the part of copyists are eliminated. It is, of course, well known that printing telegraph systems of the Hughes, Phelps and Baudot order have been in practical operation for many years on both sides of the Atlantic. These systems are successful so far as they go, but they are comparatively slow in operation, not attaining a rate of much more than 50 to 60 words per minute in one direction. Besides, they print the message on a paper strip which is not in favour with the telegraphing public. In America the Morse operators have, within the past ten or fifteen years, quite generally displaced the pen by the typewriter, in that way giving the public the equivalent of a printed message. These systems and methods, however, do not much enhance the carrying capacity of a wire above that of the hand-operated Morse telegraph methods.

For some years past efforts have been made in telegraph circles to obtain higher speed page-printing telegraph systems,—that is, systems by which the received message will be printed on a regular telegraph blank, ready for delivery. A number of different systems of this kind have been introduced into actual operation, namely, the Buckingham and the Barclay printers on the lines of the Western Union Telegraph Company, in America, the Murray printer on the lines of the British postal telegraph, and the Rowland multiplex printer, on some of the Italian Government lines. Each of these systems aims to increase the carrying capacity of a wire,—the Buckingham, Barclay, and Murray systems by increasing the speed of transmission, and the Rowland by increasing the number of practically simultaneous transmissions over the wire. The capacity of the Buckingham, Barclay and Murray systems, worked duplex, is about 200 words per minute on a circuit 1000 miles in length, with repeaters midway. The capacity of the Rowland printer, worked octuplex, is about 376 words per minute on a circuit of moderate length. Inasmuch as these systems represent the present highest type of modern telegraph systems, it seems evident, from the findings of the British Post Office telegraph department committee, that there is ample reward in store for the inventor of a simple and reliable direct-printing telegraph system capable of transmitting and receiving from 600 to 1000 words per minute on circuits of 200 to 1000 miles in length.

There is little hope for business success of any internal combustion turbine so far as our present knowledge carries us. This is the opinion expressed by Mr. Dugald Clerk, in a recent presidential address dealing with "The Problem of the Gas Turbine," before the Junior Institution of Engineers. Still, he says, the subject is so fascinating that many inventors and scientists will doubtless continue to investigate the problem, and possibly new solutions may be discovered which are not dreamed of to-day. In most of the recent discussions upon gas turbine problems, according to Mr. Clerk, it has been recognized that the temperatures possible in the cylinder gas engine are impossible for the gas turbine. It has been fully proved by many investigators that the temperatures quite common in ordinary gas engine practice range as high as 2000 degrees C., although in the best practice, for most economical results, 1500 or 1600 degrees appear to be an upper limit. With these temperatures a first-class modern gas engine of about 50 H. P. will give an indicated efficiency of 35 per cent. At the same time the negative work of

the cycle is so low that the mechanical efficiency of the engine may be as high as 86 per cent., or even over. If one realizes what the temperature 2000 degrees C. means, it becomes very evident that no turbine constructed either on the lines of Parsons or De Laval could possibly be made to work with continuous supply of such gases; 2000 degrees C. are considerably over the melting-point of platinum. This temperature is much higher than the temperature at which cast iron flows from the crucible, or, indeed, the temperature of the interior of the blast furnace itself. Any blades of iron, steel, or, in fact, of any other material, even brick-fire itself, becomes fluid or semi-fluid at this temperature. It is obviously hopeless, therefore, to attempt, in the gas turbine, temperatures which are quite feasible in the cylinder engine. This fact is generally recognized. It is accordingly said, by those who take a favourable view of the gas turbine, that it is necessary to supply the turbine with gases at a much lower temperature. One authority fixes the temperature of 700 degrees C. as one which steel turbine blades would probably stand, without too rapid deterioration. Mr. Clerk, however, maintains that oxidation of steel, and even iron, is a fairly rapid process at this temperature. Nothing new has been proposed as to the thermodynamic cycle of the gas turbine, so that all reasoning upon efficiencies depends upon the deductions already made from internal combustion engine practice.

Seeing the impossibility of constructing a turbine with materials to stand a high temperature, many have proposed to convert high temperature into kinetic energy, so that instead of having work stored up in the gas in the form of heat, the heat shall disappear, and the energy of the heat be transformed into motion of the gaseous particles at a high velocity. Such proposals, then, include the compressing of a gaseous mixture to, say 50 pounds or 60 pounds above atmosphere, the igniting of that mixture within a combustion chamber at constant pressure, and the expansion of the mixture through an expanding jet of the De Laval type, so as to drop the temperature and obtain its equivalent in kinetic energy of velocity of the gaseous particles. The rapidly moving particles at the relatively low pressure and temperature are then allowed to impinge upon rapidly rotating blades of sickle configuration, and they are supposed to give up their energy of motion to those blades, and so expend work upon the turbine. This appears to be the most feasible of all the gas turbine proposals. But even with this the theoretical and practical difficulties are considered so serious by Mr. Clerk as to warrant the conclusion expressed at the beginning of the first of these paragraphs.

A remarkable feature of electrical applications is the quickness with which they invade fields of human activity, previously long noted for conservatism. The use of the incandescent lamp in church illumination is a case in point. During the early days of electric lighting the thought of lighting a church by electricity was regarded as little short of sacrilegious by many people, and the suggestion of introducing special lighting effects about the chancel and altar was for a long time regarded as intolerable. Gradually these hostile views were lessened, as secular experience demonstrated the beauty, cleanliness, and entire inoffensiveness of electric illumination, until to-day we find some of the most artistic electric lighting in the world inside the doors of the church. Even the liturgy in the vicinity of the altar has been made more impressive by the tasteful introduction of special electric lighting effects.

Of late the illuminated sign has come into play in that class of church work which bears directly upon neighbourhood problems. In the case of churches which are active in the week as well as on Sundays the illuminated sign ought to be a real help, whether it is arranged as a transparency or as a changeable letter sign, announcing the main points of the meetings as they occur. Good taste is, of course, a most important consideration in the use of electric signs upon the exterior premises of churches. The cost of operating a sign is such a small percentage of the cost of lighting a church that it ought to be an easy matter for the central station man to extend his business in this direction. The Sunday night load comes at a time when the station output is low, and for this reason the business deserves pretty reasonable rates. The electric motor has invaded the church organ field to the lasting satisfaction of everybody; electric control of organ pipes enables the production of effects impossible in any other way through the saving of time which special keys permit, and even the telephone has been pressed into service in sporadic cases for the benefit of feeble ears. The electric sign is following suit, and from the mission chapel to the large church it ought to find a wide field of usefulness.

Social betterment methods in Germany, — workingmen's model dwellings and towns and the like,— have prompted the writing of an article by Eugen Katz, in the Berlin "Nation," which severely arraigns a number of prominent German industrial establishments in connection with which such methods have been put into practice. One of the principal German schemes, according to Mr. Katz, as quoted in "Public Opinion," is to build houses for the employees and to make the contract of rent an integral part of the labour contract. According to this contract, the lease of the house ceases with the end of the labour contract, although there may be a clause providing for eight or fourteen days' notice before the workman can be expelled. Thus the man without work is put with his family at once upon the street, and some mines, as the Louise Tiefbau, even compel the workman to leave the house the instant the contract of labour comes to an end. If the workman is married and has children, the amalgamation of the contract of rent with the labour contract means possible ruin for himself and his family. But in the majority of instances there is no need to apply the screws,—the mere threat is sufficient; the fact that the labour and rent contract is combined was also one of the real causes why the recent strike among the German miners came to an end. It is, therefore, evident that providing clean, hygienic houses for the workmen is merely a means of compulsion in the hands of the employer. A still more intolerable situation is presented in those cases in which the houses are let only to families which agree collectively to work for the employer or company, and there are frequent instances in which child workers, sometimes even in spite of ill health, are compelled to enter the factory.

Still more obnoxious are the conditions when the house is built by the workman with money loaned by the employer. In this case the workman is not only shelterless in case he leaves his place, but he faces a far greater loss. As the man cannot pay back the money in the great majority of cases, the house is sold at auction; but it is doubtful if a price is ever obtained which covers the original expenditure and thus returns to the workman what he has expended. Another scheme is that of compulsory insurance funds. Here the

workman, if he leaves the employer, not only loses all possibility of receiving his insurance, but in addition he loses all he has saved. In one case, according to Mr. Katz, in the last seven years no less than 31,000 men have lost their savings without the return of a single penny.

Locomotive service has been stated to be more favourable to the use of steam superheating than any other in which it has been tried. In a lecture before the Franklin Institute, Professor W. F. M. Goss explained this as being due to the following circumstances: — In stationary or marine practice, where the superheater is either a separate boiler-like device, in which no water is carried, or is so combined with the boiler as to always be in close communication with its furnace, the circulation of steam within the superheater tubes ceases when the engine throttle is closed, and the metal of the tubes, together with the entrapped steam within them, remains exposed to the undiminished intensity of the furnace action. The tubes are thus often heated to very high temperatures, a result which, when frequently repeated, leads necessarily to a failure of the superheater. Again, when after an interval of inactivity, the engine is started, the steam which has been held back within the superheater until it has been raised to an enormously high temperature, passes on to the engine, oftentimes retaining enough of its heat to burn the lubrication and sometimes to destroy the rod packings. But all difficulties of this class which, to a greater or lesser degree, have appeared in the operation of every stationary engine plant using superheated steam, are doubtless avoided in the locomotive, for in this machine the rate of combustion varies with the volume of steam used. When the throttle is open, the fire burns brightly; when it is closed, its activity is at once suppressed. When there is no steam passing within the tubes of the superheater, the gases circulating around the tubes are comparatively low in temperature, and when the conditions are so changed that the temperature of the gases becomes maximum, the volume of steam passing through the tubes is greatest. Just as the draught of a locomotive responds to the varying demands which are made upon the boiler, so the volume of heat which is available for superheating varies with the quantity of steam which is to be superheated.

HENRY GORDON STOTT

Superintendent of Motive Power of the Interborough Rapid Transit Company, New York

A BIOGRAPHICAL SKETCH

Of Henry Gordon Stott, whose portrait appears in this issue as a frontispiece, it was said recently that, as superintendent of motive power of the Interborough Rapid Transit Co., of New York, he had under his supervision a greater amount of horse-power than anyone else in the world.

To be a bit more specific it should be stated that Mr. Stott's responsibility covers the entire system of the Interborough Co., both subway and elevated lines, from the coal in the mine till power is delivered to the third rail, including all the power houses and sub-stations, transmission lines, etc., this entire system giving

out a total maximum power every morning and afternoon of 100,000 KW., or approximately 134,000 H. P. While his duties have been largely in charge of the operation of this huge system, they have also included design and construction work, covering every detail of the plant, both mechanical and electrical.

For over nine years Mr. Stott was electrical engineer of the Buffalo General Electric Co. His first work there was to install an underground cable,—the first one used in Buffalo, and while his services were originally engaged for only three months, he was eventually retained as their electrical engineer and served in that capacity until he severed his connections with them to join the Interborough Rapid Transit Co., of New York

Mr. Stott received his early education by being privately tutored by his father,—the late Rev. D. Stott, of Orkney, Scotland. Later on he attended the Watson College School, of Edinburgh, and also the public schools, afterwards taking the engineering course in the College of Science and Arts, Glasgow,—now a part of the Glasgow and West of Scotland Technical College,—and for three years devoting particular attention to electrical engineering. After a few months' service in Glasgow with a local central station company, Prof. Andrew Jamieson, of the Glasgow and West of Scotland Technical College, succeeded in having him appointed assistant electrician of the Anglo-American Telegraph Company's cable ship "Mina."

After four and a half years' service on the cable ship, Mr. Stott realized that the lighting and power transmission fields offered much greater inducements than did telegraphy. He consequently resigned to accept a position with the Brush Electrical Engineering Co., of London, England. His first year with this company was spent for the most part in their central station at Bournemouth, England, after which he went to Madrid, Spain, as engineer for the contractors who were to erect and equip a central station at that place. The duties there also included the laying of underground cables and installation work. After this plant was completed he returned to the Brush Co., in London, and for some time was engaged in underground cable construction. This was his last work before starting for America. Upon his arrival in New York he was at once engaged to do the underground cable work in Buffalo previously mentioned.

Mr. Stott is a member of the American Institute of Electrical Engineers, of the American Society of Mechanical Engineers, and of the Engineers' Club, of New York. He is also a manager of the American Institute of Electrical Engineers, vice-president of the New York Electrical Society, and a member of the consulting staff at the Brooklyn Polytechnic Institute.

Manufacturing News

The Mechanical Transport of Air

THE problems involved in the transportation or movement of fluids differ essentially from those concerned in the moving of solid materials. In the case of the latter the conveyance of the body consists in the actual lifting and carrying; in the former, the movement results from and is proportional to the pressure difference existing between the delivering and receiving points.

The highest efficiency results from low-pressure differences and large conduits which permit of the lowest velocity and least friction. It is here that the fan blower finds its opportunity for greatest usefulness. As developed by the B. F. Sturtevant Company, blowers are built in several hundred types and sizes for handling air up to 1 pound pressure per square inch. Steel pressure blowers deliver air at high pressure but in small volume. Monogram type blowers and exhausters operate at somewhat less pressure but discharge more air. Steel-plate fans are primarily designed to handle large volumes at very moderate pressures. They are especially adapted for ventilating, heating and drying systems, mechanical draft, and the like. They are arranged to be driven by belt or by direct-attached engine or motor. Electric propeller fans are designed for pressures under $\frac{1}{2}$ ounce per square inch.

As our readers doubtless know, the business of the B. F. Sturtevant Company, of Boston, Mass., was primarily the manufacture of blowers. This naturally led the business into various allied branches, such as the building of heating, ventilating and mechanical-draft apparatus, etc., as well as the manufacture of engines and motors to operate the blowers, and later of generators for use in connection with the engines for electric lighting, both in stationary power plants and in marine service. More recently has been added the manufacture of economizers, exhaust heads, etc. These several products are distinctly different in character, some being such as can be readily manufactured on the interchangeable plan, while others, like heating, ventilating and mechanical draft apparatus, must each be built to meet the needs of each individual customer. Such apparatus is, however, largely made up of standard machines by the assembling of such sizes of engines, motors, blowers, etc., as may

be needed to meet the requirements, the special work thus consisting mainly in sheet metal work, the piping, framing, etc., which is necessary in each case.

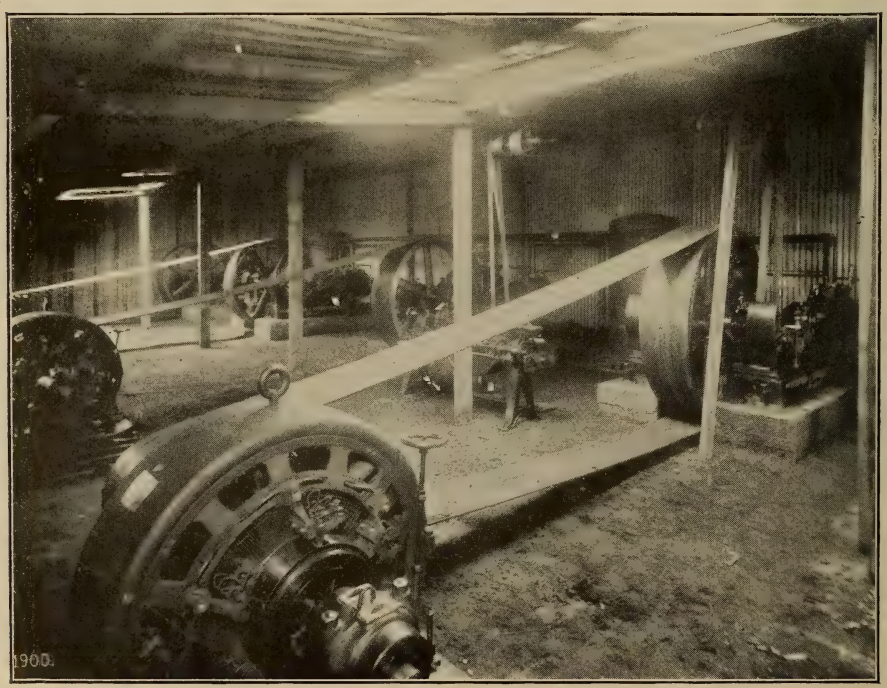
An Air Power Plant

WHEN it was decided to use electric motive power on the London Metropolitan Railway, one hundred new steel cars were needed. The contract for these cars was secured by the Amercian Car & Foundry Company, of New York, under conditions demanding the highest possible speed of construction. The work to be done called for a great number of pneumatic tools, and since the contract covered only a short period, the plant installed was of a temporary character.

The order for the complete pneumatic equipment was placed with the Ingersoll-Sergeant Drill Company, of New York and London, and the appliances furnished were of the company's standard types. The tool equipment proper included eighteen 8-inch and twenty-five 5-inch Haeseler riveting hammers; also sixteen No. 7 and twenty-four No. 12 Haeseler rotary drills,—eighty-three in all.

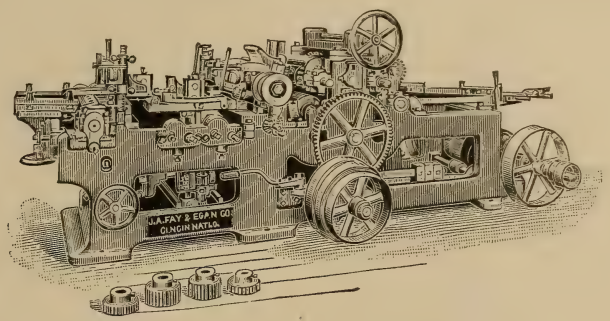
The accompanying illustration shows four air compressors furnishing power for the tools just mentioned. The compressors are duplex two-stage machines of the balanced type, with a heavy inside fly-wheel, solid sub-base, and semi-tangye frames. The heads and barrels of the air cylinders are completely water jacketed, and an intercooler in the sub-base beneath the cylinders provides inter-stage cooling. The Sergeant piston inlet air valve is used on each of the cylinders, and vertical lift direct-discharge valves are employed.

At a rate of speed of 150 revolutions per minute, each compressor has a



THE PNEUMATIC EQUIPMENT IN THE PLANT OF THE AMERICAN CAR & FOUNDRY COMPANY, SUPPLIED BY THE INGERSOLL-SERGEANT DRILL COMPANY NEW YORK AND LONDON

displacement of 526 cubic feet, giving a total free air capacity to the plant of 2104 cubic feet per minute; this is delivered at a pressure of 80 pounds.



AN INSIDE MOULDER FOR WORKING HEAVY MOULDINGS. MADE BY THE J. A. FAY & EGAN COMPANY, CINCINNATI, O.

Each compressor is belted to a direct-current British Westinghouse motor rated at 110 horse-power on 550 revolutions per minute. Standard automatic choking controllers on the compressors maintain pressure and regulate the output as the load varies.

The illustration shows the temporary nature of the plant,—the cheap, shell-like building, the unfinished foundations, the rough earth floors. But it will be noted that the details in the machinery equipment have been given considerable attention.

An Inside Moulder

THE inside moulder shown on this page is made by the J. A. Fay & Egan Company, of Cincinnati, Ohio, for working heavy mouldings for cars, furniture, flooring and ceiling. It will work up to 6 inches in thickness, and is made in two widths,—12 inches and 15 inches, respectively.

The frame is square, open built, and ribbed inside. The upper cylinder is belted at each end and mounted in a housing, whereby both bearings are yoked together for securing alignment. The housing is raised by two screws mounted on ball bearings and simultaneously operated by a crank, which is locked in position by bolts passing through the body of the housing. The lower cylinder is placed at the feed-out end of the machine, and is belted on the right end only, leaving the left side of the machine clear for access to the heads and guides. This cylinder is carried in a frame vertically adjustable by means of a hand-wheel, and both cylinder housings have also a screw adjustment across the machine for truing up the cut of the heads after the knives have been set.

The chip breaker is made in sections, each of which is independently adjustable to clear the protecting knives and still maintain the pressure close to the cut of the cylinder. The side heads are made to swing large cutters, the spindles being $1\frac{1}{2}$ inches in diameter where the heads are applied. The side-spindle housings have vertical and angle adjustments, and also a horizontal movement entirely across the machine; they can be locked in position. In addition the spindles have a vertical adjustment in their housings, permitting the heads to be accurately lined up while the machine is running. Adjustable throat pieces are provided for the matchers to give support to material whether large or small cutters are used.

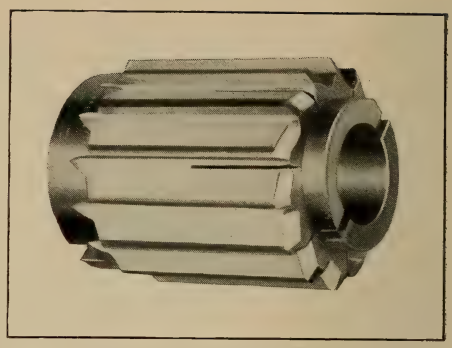
There are four feed rolls, 7 inches in diameter, and driven at each end by heavy gears. The top rolls are

mounted in housings carried by one pair of slides mounted in the sides. These are connected at the top by a stretcher which carries the raising shaft and hand-wheel, by means of which both slides are raised simultaneously. The top rolls are made in sections, and the shafts may be withdrawn at the side of the machine to permit interchanging for either smooth or fluted rolls. When the roll shafts are withdrawn, the roll gears do not drop out, as they are carried on independent sleeves, and thus are maintained in position in mesh with the driving gears. The feed of the machine is driven by cone pulleys giving three speeds of feed,—15, 30, and 45 feet per minute, and is regulated by means of a clutch lever either at the feed-end of the machine or at the left side near the matchers. The tight and loose pulleys are 14 inches by 8 inches face, and should make 750 revolutions per minute.

An Expanding Shell Core Drill

THE Three Rivers Tool Company, of Three Rivers, Mich., make the expanding shell core drill shown herewith, in sizes from 4 to 6 inches. These tools are expanded by taper plugs screwed into their ends, which are made hollow. Among the advantages claimed for these tools are the following:—

They have the full number of cutting edges used for tools which are not expanding; they have no loose blades, the inserted blades being brazed rigidly in their places; the expansion takes place where the tool wears; the expansion can be made instantly, and to the desired amount without requiring special wrenches; the expansion can be made while the tool is in the machine; their cost is about half that of such tools made with solid high-speed steel; being made of soft steel, they are not so liable to break when expanding as are such tools made of solid high-speed steel.



AN EXPANDING SHELL CORE DRILL MADE BY THE THREE RIVERS TOOL COMPANY, THREE RIVERS, MICH.

The expanding shell core drills made by the Three Rivers Tool Company fit standard shell arbours by turning down the outer end of the arbour so as to fit the straight hole in the expanding screw.

A New Mine Pump

ONE of the recently designed mine station pumps built by the A. S. Cameron Steam Pump Works, of New York, is shown, together with some details of its construction, in the accompanying illustrations. This pump is known as their outside packed, plunger pump with pot valve water end, and compound steam cylinder, and is shown complete in Fig. 1.

Fig. 2 shows very clearly the construction of the cylinders, both being made of hard, close-grained iron, and of ample thickness to allow reboring if necessary. The steam ports are of such size and arrangement as to allow the pumps to be operated at a high speed. The connections between the steam and the water ends are made by means of steel tie rods, two on each side; these are bolted to the lugs on the sides of the cylinders, and so arranged as to allow the low-pressure cylinder heads to be removed at any time. This is claimed to give complete accessibility to the low-pressure steam piston, as well as

enabling the removal of the plunger when necessary without dismantling the pump.

The water end consists of two working barrels and four valve chambers, the latter being commonly called "pots." There are two water plungers connected to the outside rods, and they are the only moving parts in the water end, except the valves, coming in contact with the water. The plunger works through stuffing boxes, which are lined with acid-resisting bronze bushings that can be removed and renewed when necessary.

The interior arrangement of the valves and chambers is clearly shown in Fig. 3. These chambers contain separate water valves. Valve seat *3* is a substantial acid-resisting bronze casting, securely held in place. The valve *4* is a rubber disc, and is protected by the heavy bronze guard *5*, which also serves as a stem working in the guide *7*. A section of the spring is also shown at *6*. The use of a large single water valve in each of these chambers, instead of groups of smaller valves, allows the passage of comparatively large solid bodies, such as pieces of coal and dirt, which may enter with the water, and would otherwise clog the valves. Each of

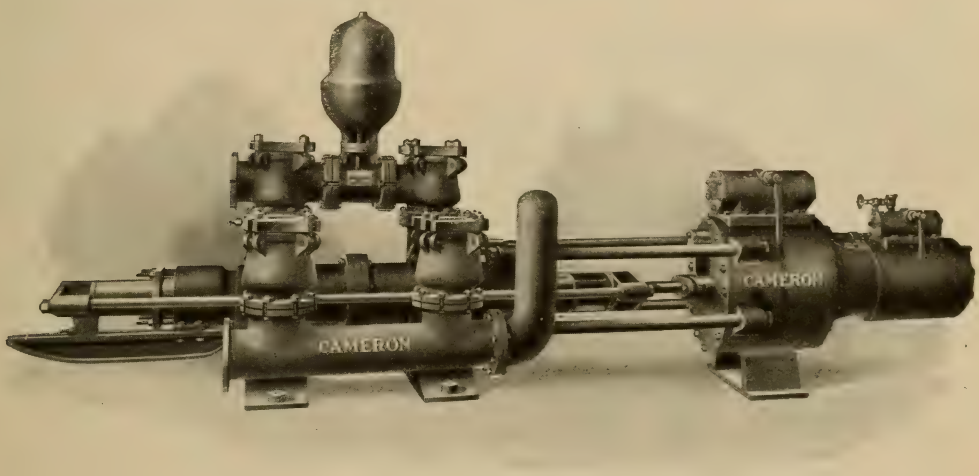


FIG. 1.—A NEW MINE PUMP BUILT BY THE A. S. CAMERON STEAM PUMP WORKS, NEW YORK

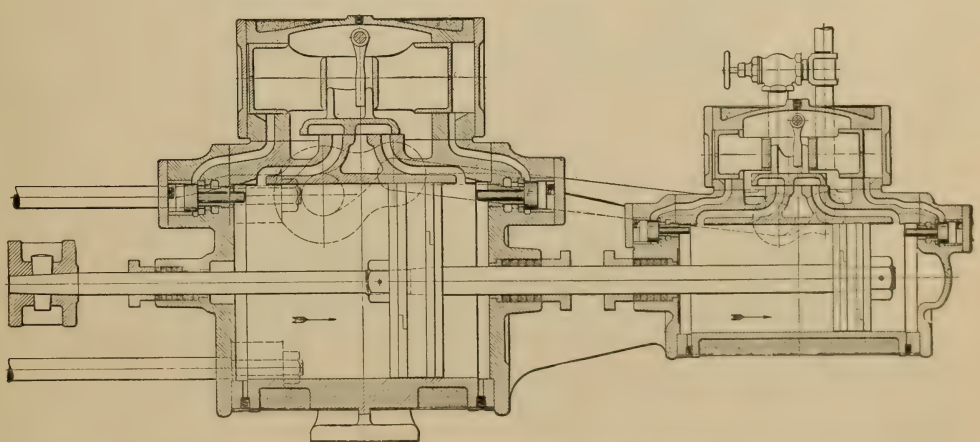


FIG. 2.—A LONGITUDINAL SECTION OF THE STEAM CYLINDERS

the chambers is fitted with covers held in place by four swing bolts, so as to make the water valves easily and readily accessible.

A distinctive feature claimed for these water cylinders is that the metal throughout is of extra thickness, and in addition, when necessary to resist corrosion, is wood-lined with sound white pine, as shown at *9*, which is securely wedged in place so as to be water-tight. All the water passages can be provided with either wood, bronze, or lead linings, to meet the varied requirements, and these linings can be replaced when necessary at low cost. The velocity of the passage of water through the valves and chambers is reduced to a low rate by ample valve area and large water passages.

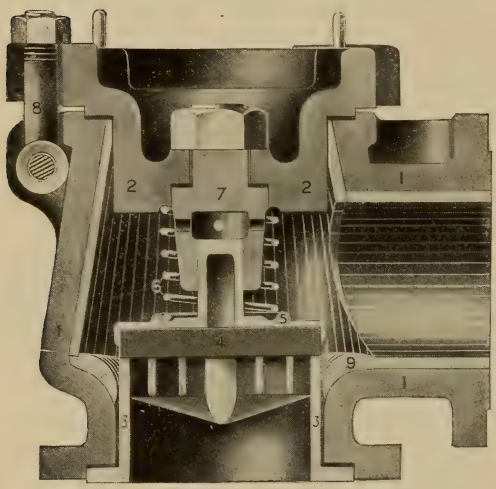
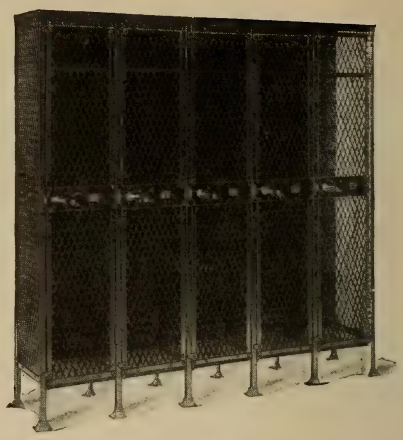


FIG. 3.—SECTIONAL VIEW OF THE VALVES AND CHAMBERS IN THE NEW CAMERON MINE PUMP

A New Metal Locker

THE metal locker shown in the accompanying illustration is made and installed by the Edward Darby & Sons Company, Inc., of Philadelphia, Pa. It is made of expanded metal, which latter is made from planished steel plate, cut, expanded, and then rolled so that it presents a smooth surface, free from rough edges or corners.



A METAL LOCKER MADE BY THE EDWARD DARBY & SONS COMPANY, INC., PHILADELPHIA, PA

Owing to the open mesh used, the locker is thoroughly ventilated. It is equipped with one shelf, three nickel-plated coat hooks, brass number plates, and a three-point locking device which fastens the door at the top, center, and bottom with a single turn of the locking lever. The locks are provided with two non-changeable keys, and each set is master-keyed. The lockers are made in groups and sizes according to requirements.

An Electric Emery Grinder

THE electrically-driven emery grinder shown on the next page is built by the Stow Manufacturing Company, of Binghamton, N. Y. The principal advantage claimed for this grinder lies in the specially designed multi-speed electric motor employed to drive the machine. The speed of the motor is mechanically regulated by turning the hand-wheel shown on top of the machine. No controller or rheostat is used, the power apparatus is entirely self-contained, and it is claimed that the regulation of speed is all that can be desired.

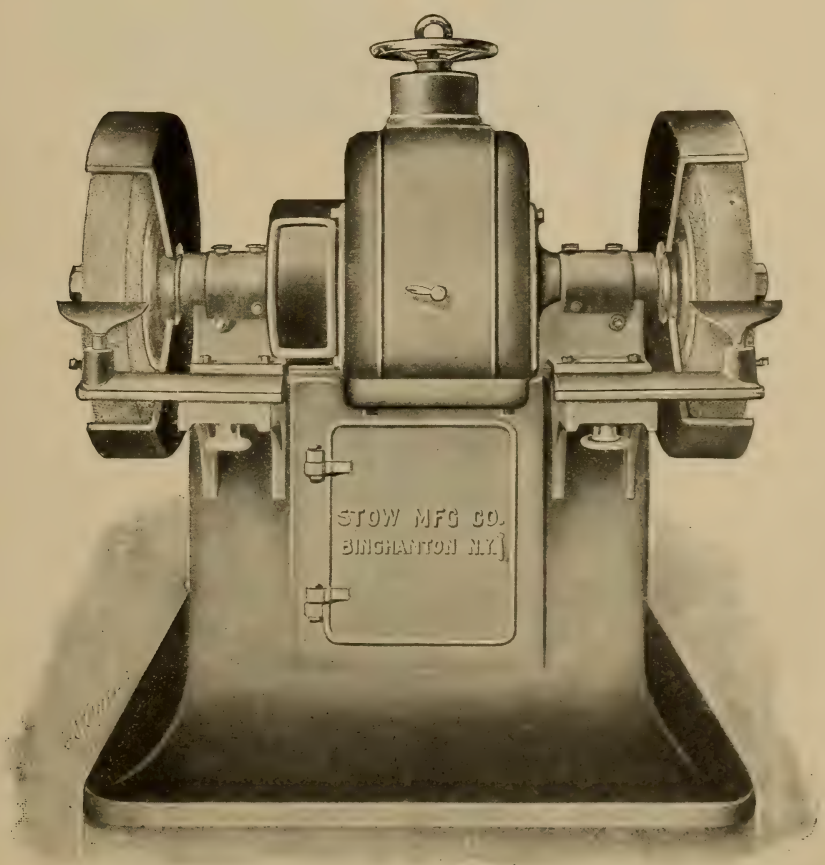
Two emery wheels, 3 by 24 inches,

are used on this grinder. They may be run either wet or dry, or a dry wheel may be placed at one end and a wet wheel at the other. Both wheels are provided with detachable rests for grinding, and also catch pans into which the water spray is thrown and returned to the water tank. The motor is designed to run on direct current only, and is started or stopped by turning the short lever on the motor either to the right or left. There is claimed to be no appreciable vibration of the machine while in operation.

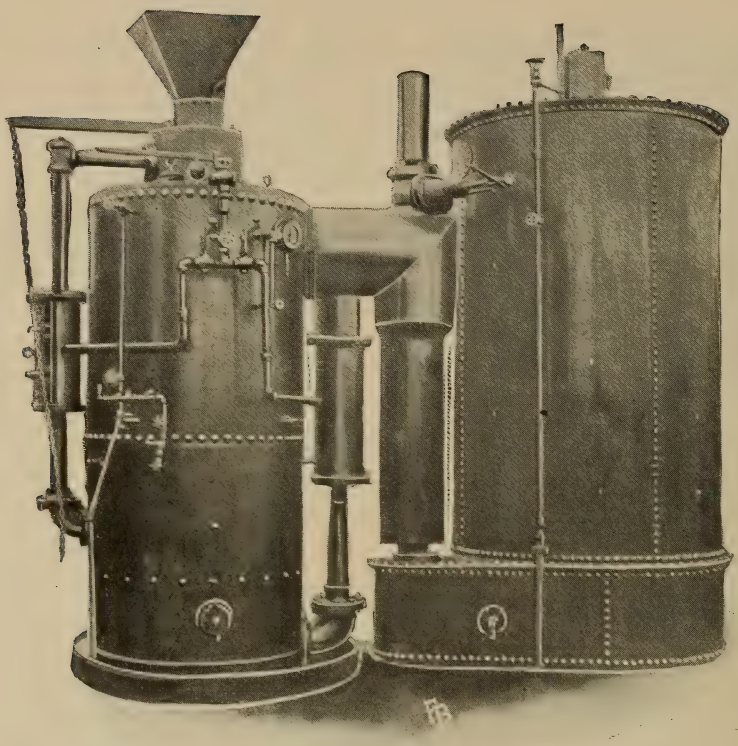
An Automatic Gas Producer

THE gas producer shown in the annexed cut is made by the Automatic Gas Producer Company, of New York, and consists of two parts,—the producer and the purifier.

The producer is surrounded by a water jacket, forming a boiler, and is built of heavy steel plates. Its interior, into which bituminous coals are fed, is a cast-iron retort. From the top of this retort is piped a connection down to and into the fire-bed. In this connection is set a steam jet blower. The coals in the retort are subjected to the heat of the gases blasted from the fire underneath on their way out of the producer, and this heat is sufficient to cause them to throw off their volatile portions, which are exhausted by the jet blower and forced into and through the fire below and



AN ELECTRIC EMERY GRINDER BUILT BY THE STOW MANUFACTURING COMPANY, BINGHAMTON, N. Y.



A GAS PRODUCER MADE BY THE AUTOMATIC GAS PRODUCER COMPANY, NEW YORK

changed to producer gas. This gas, if taken off by itself, would be rich in heavy condensible hydrocarbons, but by forcing it up through the fire-bed, they are changed into producer gas, increasing its volume and calorific value.

The coal which is fed into the retort, after reaching the blast in the producer, is no longer coal, but coke. The bottom of the retort acts as a distributor and keeps the fire-bed level.

In the wash box of the purifier, the gas, instead of coming up at the end of pipe seal in large globules, is distributed the entire length of the wash box, passing up through thousands of small holes, which break the gas into small globules so it is quite thoroughly washed. It is then made to travel a long distance through wet coke for further purifying it, this distance of travel being caused by shelves with opposed openings. The two top shelves are purifiers, and these complete the cleaning process, the gas then passing from the purifier to the engine.

One of the automatic features claimed for the producer is its self-control of the amount of gas generated or blown. A regulator is attached to the steam valves, and the pressure of gas in the purifier operates this regulator, so as to keep an even pressure of gas ready to blow up to its capacity, or to run on any reduced amount required.

This producer is primarily intended for use with bituminous coals, but lignite, anthracite, coke, charcoal, or wood can be used without change. The capacity of the producer is calculated on the basis of 10 pounds of coal per square foot of grate area.

A Hydro-Pneumatic Accumulator

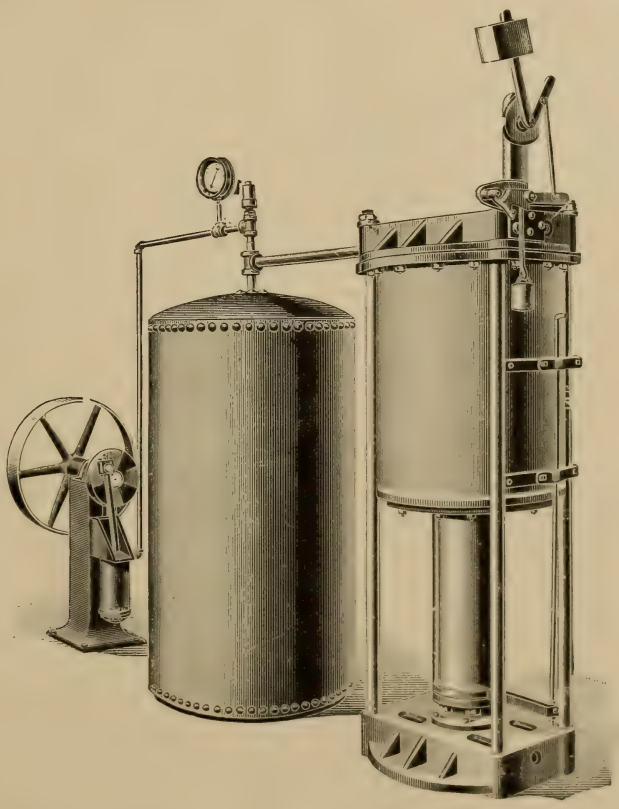
FOR situations where it is not desirable to use either a weighted or steam-loaded accumulator for either a single press or a system of presses or tools, as, for instance, inside a light building, on an upper floor, or for semi-portable outfits, the hydro-pneumatic accumulator made by the Watson-Stillman Company, of New York, and shown herewith, is adapted.

The outfit consists of four elements. First, the pump, which can be either of the belt or steam-driven type. Second, an intensifier, which has the high-pressure end connected to the pump delivery pipe, and the other end connected to the third element,—a heavy tank designed especially for each combination. Fourth, a belted air-compressor, with which to obtain the desired initial pressure or to replace loss from leakage of air or by its absorption. These accumulators are regularly designed for a maximum air pressure of 200 pounds per square inch. This, however, can be varied at will, thereby reducing the hydraulic pressure proportionately.

A Naval Station in the Far East

THE United States Government has awarded to J. G. White & Co., of New York, a contract for the construction of a naval coaling station, complete, with equipment, at Olongapo, on Subig Bay, in the Philippine Islands.

The installation will constitute one unit of six, which will ultimately be built, providing a coal storage of 120,000 tons for the use of the United States Navy. The initial unit will cost



A HYDRO-PNEUMATIC ACCUMULATOR MADE BY THE WATSON-STILLMAN COMPANY, NEW YORK

approximately half a million dollars and will require two years to complete it.

Subig Bay, about 75 miles north of Manila, is one of the finest harbours in that part of the world. It was originally intended to establish a naval base at Cavite, but the Board of Army and Navy Officers decided in favour of Subig Bay in preference to both Cavite and Guam. The harbour will be heavily fortified, and it is estimated that it will require an expenditure of between $10,000,000 and $15,000,000 to carry out the work now proposed. A large part of the bay will be dredged to a depth of 35 feet, this being sufficient for the largest battleship in the navy.

The coaling plant will consist of apparatus for unloading coal from vessels or cars, and storing it, together with means for reclaiming the coal from storage and delivering it to vessels or cars again. A large water-storage tank, having a capacity of 50,000 gallons, will be located on top of a nearby hill, and a pumping plant provided to supply it with water from the Benictigan River, about one mile and a half from the station. This water will be used for fire purposes in connection with the coaling station, or for the use of vessels.

The coaling unit about to be installed will be built upon a wharf 250 feet long and 75 feet wide. This wharf will be set upon clusters of piles which will be enclosed in concrete for protection. The dock of the wharf is of steel and concrete. From the outer edge of the wharf a steel and concrete coal bunker will be erected, having a capacity of five tons of coal per running foot. It will be provided with chutes for delivering coal upon the decks of vessels or into cars. An electrically operated movable coal unloading tower, constructed of steel, will be operated on a track extending along the top of the coal bunker. It is designed for taking coal from cars on the landward side of the wharf, or from colliers on the seaward side, and delivering this coal either into the bunker or upon a conveyor which will carry it to the coal storage building. The conveyors will have a capacity of from 100 to 150 tons of coal per hour. The coal storage shed will be a steel structure, with a concrete floor 450 by 150 feet, and will hold approximately 15,000 tons. The enclosure will be divided by concrete partition walls so that the greatest amount of coal in one pocket will be 600 tons, thus preventing the spread of fire, which is liable to occur spontaneously where large masses of bituminous coal are stored.

Electric thermostats will be located at 20-foot intervals, and will ring an alarm in the office of the superintendent should the temperature of the coal rise above a fixed point. All the conveyors and other apparatus for handling the coal will be electrically operated, and the power house will be installed adjacent to the coal storage building.

This unit as described, will be supplemented from time to time by other units of similar size and type, the wharves extending continuously along the bay front. Each wharf will accommodate a battleship, which can be coaled to the extent of 2000 tons, in less than half a day. All of the coal used will be brought from the Virginia coal fields in tramp steamers, via Suez.

The cost of the American coal is practically $8 a ton at Subig Bay, as against $5 for Japanese coal, and $5.50 for Australian coal. The American coal is, however, of a considerably higher grade, and is said to be much better adapted for use under the marine boilers.

In conjunction with the coal station, extensive marine and repair shops will be built, in which repairs of any kind can be carried out, and small cruisers and gunboats entirely constructed. Large floating docks will also be built to accommodate the largest vessels in the United States Navy.

Modern Friction Clutch Uses

REFERRING to the illustrated description in the October, 1905, number of the friction clutch made by the Carlyle Johnson Machine Company, of Hartford, Conn., the makers advise us that the clutch is not a new one, but has been before the public quite a number of years.

The special point to which they desire to have attention directed is a new use for the clutch,—using it on a factory line shaft and thus enabling a group of machines, each with its own clutch, to be run direct from the line shaft instead of having a separate countershaft for each machine. The saving in power, pulleys, countershafts, and overhead or cross belts, the maintenance of which is a constant item of expense and amounts to considerable each year, is claimed to soon pay for this equipment. With no overhead belts, the room is much lighter, cleaner and neater.

In contemplating the building of new factories, or remodeling old ones, this plan is worth consideration.

New Trade Catalogues

AMONG the latest catalogues is one brought out by the Brown & Sharpe Manufacturing Company, of Providence, R. I., illustrating and describing their complete line of machinists' tools. This catalogue contains 164 pages, is thoroughly indexed, and is of a very convenient size for reference.

Equally neat and attractive is the new catalogue issued by the Standard Roller Bearing Company, of Philadelphia, Pa., treating of the ball and roller bearings made by them.

Patterson, Gottfried & Hunter, of New York, have two very complete catalogues entitled, respectively, "Blacksmiths' Tools" and "Power Transmission Appliances." Each of these publications contains over 250 pages and gives descriptions, illustrations, and prices of the tools and appliances made by this firm.

"Bulletin No. 1," recently brought out by the Olds Gasoline Engine Works, of Lansing, Mich., treats of the gasoline engines they build in sizes up to 7 horse-power.

The Wellman-Seaver-Morgan Company, of Cleveland, Ohio, have a new catalogue on ladle, overhead traveling, gantry, and locomotive cranes.

Among the new publications issued by the Allis-Chalmers Company, of Milwaukee, Wis., are the following:—Catalogue No. 127, treating of sampling plants and equipment; Bulletin No. 1405, on portable rock-crushing plants; Bulletin No. 1406, on forged steel balls; and Bulletin No. 1407, on the Bennetts pouring spoon. They also have new descriptive matter on sawmill carriages, steam shovels, jigs for mining, roasting furnaces, pumping engines, and centrifugal pumps.

The Coates Clipper Manufacturing Company, of Worcester, Mass., in a new bulletin illustrate and describe the construction and applications of the ball-bearing flexible shaft made by them.

Stone channelers as built by the Ingersoll-Sergeant Drill Company, of New York, are well presented, both as regards their construction and operation, in a new catalogue.

Warren Webster & Company, of Camden, N. J., furnish some interesting matter on the Webster water-seal motor. This motor is for use only in connection with the Webster system of steam circulation.

The "two in one" hoisting drum made by The Hayward Company, of New York, is treated of in a new booklet. This device, as its name implies, consists of two drums mounted on the same bed-plate, and acting as one drum.

The Jeffrey Manufacturing Company, of Columbus, Ohio, have issued a new bulletin on mining machinery; it is devoted especially to electric mine locomotives as built by them, and is profusely illustrated and well written.

The Westinghouse Electric &

Manufacturing Company, of Pittsburg, Pa., have issued a booklet on rotary converters. This explains the characteristics and construction of Westinghouse rotary converters, and gives instructions for their erection, operation, and care. The subjects are well presented, and the publication forms withal a valuable reference book for the electrical engineer. Railway motors for direct-current service, and railway apparatus in general, are treated of in new publications issued by this company, and they also have a new circular illustrating and describing their prepayment wattmeters.

Electric storage batteries of the unit accumulator type for car lighting are illustrated and described in a bulletin issued by the National Battery Company, of Buffalo, N. Y.

The National Electric Company, of Milwaukee, Wis., have issued a new bulletin treating of the belt-driven alternating-current generators built by them.

Bulletin No. 75, entitled "Mechanical Draft; What It Is, What It Does," has just been issued by the B. F. Sturtevant Company, of Boston, Mass. This booklet not only briefly presents the salient features of this system of draft production, but illustrates a variety of plants which clearly show "what it is." The suggested query in the words "what it does" is answered thus:—It does what an ordinary chimney is incapable of doing. Its cost is from 20 to 40 per cent. that of a chimney; its intensity permits of the burning of finely divided or low-grade fuel; it makes possible the utilization of the heat of the flue gases which a chimney wastes in producing draft; it is independent of the weather; is automatically regulated to maintain constant steam pressure, decreases smoke, increases the capacity of an existing plant, and serves as an auxiliary to a chimney already overburdened, saves space, and is portable.

"Notes on the Principles and Performances of the Balanced Compound Locomotive," is the expressive title of an attractive publication recently issued by the Baldwin Locomotive Works, of Philadelphia, Pa. This publication is known as "Record of Recent Construction, No. 53" and contains much of interest to those who have to do with steam locomotives.

The Lawrence Machine Company, of Lawrence, Mass., have a new catalogue describing and illustrating their centrifugal pumps and vertical steam engines.

Clipping and riveting hammers, drills, hose couplings, and other pneumatic appliances made by The Cleveland Pneumatic Tool Company, of Cleveland, Ohio, are treated of in a catalogue recently issued.

The American Steam Pump Company, of Battle Creek, Mich., have an interesting catalogue, lately brought out, on tank and vacuum pumps. The various styles of pumps made by this company are illustrated, and their details and sizes are given in tabulated form.

The Pittsburg Transformer Company, of Pittsburg, Pa., have issued a new publication to show the practicability of thawing frozen pipes by means of electricity, and also to call attention to their new electric thawing outfit.

"Steam Hoisting Engines" is the title of a publication brought out by the C. W. Hunt Company, of West New Brighton, N. Y.

Horizontal and vertical power pumps as made by F. E. Myers & Bro., of Ashland, Ohio, are treated of in a new catalogue.

The Watson-Stillman Company, of New York, have issued three new sheets relating to the coupling-bolt forcers they have built within the last few years.

A new catalogue of the Otis Elevator Company, of New York, illustrates and describes in general the elevating machinery and apparatus made by them.

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